

The Blast Furnace *and* Steel Plant

Iron and Steel Institute Meeting

Patriotism Dominant at Thirteenth General Meeting of American Iron and Steel Institute—Steel Producers Pledge Themselves to Support of the Government—Five Hundred Members Present.

PATRIOTISM was again the predominating note of the thirteenth general meeting and the second "war" meeting of the American Iron and Steel Institute, held at the Hotel Sinton, Cincinnati, October 26-27, at which the support of the steel producers of the United States was pledged to the government. President Elbert H. Gary opened the morning session, reviewing the activities of the general committee and sub-committees of the institute and emphasizing the present strength of our enemies and the consequent necessity of increased production. Referring to the appointment of the committees announced at the last meeting of the institute he stated that it had been deemed necessary to abrogate the appointment of these committees resulting in the appointment of a general and sub-committee representing the different special lines of the industries, which committees had from time to time been reporting their recommendations to the War Industries Board at Washington. This board in turn has reported its recommendations to the President for decision. Referring to the recent price regulations, Judge Gary stated, "it is only stating facts to say that the committees have endeavored to represent the manufacturers conscientiously, intelligently and forcefully, and that the members of the War Industries Board have at all the hearings given patient attention, thorough investigation and careful consideration to every claim presented with the sole purpose of doing justice to the government and to the individual."

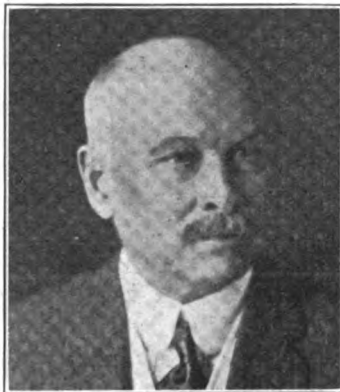
It was suggested that some of the producers would realize larger profits than others, owing to greater di-

versity of commodities, favorable location, better organization, larger production or other facilities which tend to lower costs, but these would to some degree be compensated by the progressive rates of governmental excess profit taxes. In some cases it having

been estimated that manufacturers will be obliged to pay as much as 50 per cent excess profit tax.

In regard to the work of the government in handling the war situation Judge Gary stated "there has been created a vast business organization, with scores of departments, and a larger number of sub-departments, which are carrying on the greatest of all

Elbert H. Gary's Message to Steel Producers



"Our country and its allies in the international conflict are in need of every pound of steel which can be produced in this country and which can be used for war purposes. To insure this supply, every furnace and mill having relation to the subject must, without interruption, produce to the fullest capacity and subject to the control of the government through its lawfully constituted agencies. No excuse for neglect, delay or interruption will or can be accepted by the government. So long as the attitude of those in control of governmental affairs toward producers remains as it is at the present, it must be the effort, as it will be the pleasure, of every one of the latter to do his part unselfishly, wholeheartedly and assiduously."

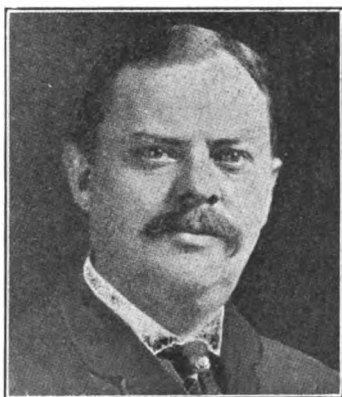
business undertakings; and, notwithstanding the unfavorable criticisms which have been made, many, if not most of which, are wholly unjustified, it should, in truth, be said that this colossal combination of diversified, ramified and intricate business activities, involving almost every phase of political, social, commercial, financial and industrial life, is being, has almost been, whipped into a smooth running machine. That mistakes have been made, that steps have had to be retraced, that sometimes action has been too hasty and other times too deliberate, that red tape rules created by legislation or otherwise, occasionally have interfered with the best results, may be assumed; but with patience, skill, persistence, vigor and success, the great varieties of business enterprise as time elapsed have been better and better coördinated and the whole structure developed nearer and nearer to the point of perfection."

Judge Gary briefly reviewed the war situation, describing the complete systematic preparation for war

which had been made by Germany, saying that "Prussian Germany was obsessed with the ambition to rule the world." He saw no prospects for an early end of the hostilities, although admitting that there was always the possibility of an unexpected break and collapse. Men, food, steel, money and credit were analyzed to be the necessary elements of strength to win the war, in all of which elements the allies at the present have a decided advantage over the Central powers.

In conclusion Judge Gary stated, "on the battlefields of Europe men are dying by thousands and tens of thousands. Our sons or brothers or other relatives will soon be active participants. I fear the rolls of the dead or injured may be brought across the ocean within a few months, although I hope for the contrary. These men who have cheerfully offered their persons as a sacrifice to a noble cause are appealing to us by thought, if not by word, for such assistance as we may render. Every dollar we expend, everything we do, every sacrifice we make will assist in protecting the lives and health of the patriots who are abroad in defense of our rights. We must not, we cannot, withhold anything that will be of benefit to those splendid men."

Cincinnati and Its Industries



DANIEL B. MEACHAM.

DANIEL B. MEACHAM, partner, Rogers, Brown & Co., Cincinnati, welcomed the institute members to Cincinnati. He spoke of the work of the American Iron and Steel Institute, and the characteristics of the "Queen City" saying:

"A distinctive and unique feature of Cincinnati is its wide variety of substantial industries. According to the United States census of 1914, in this industrial district there were 2,623 manufacturing establishments, and these included 92 of the 264 industries recognized by the census. This diversity of industries is an exceedingly valuable asset to a city, and gives it advantages over one that is dominated by a single line.

The National Social Unit Organization made a careful and widespread survey and selected Cincinnati as the most typical American city and one in which the

citizens of all nationalities and beliefs worked in best accord for social betterment, and its first experimental station is established here. Our people have a firm conviction that the real success of an industrial city rests chiefly on a well educated, self-respecting working population. Many agencies are operating efficiently to bring about the results desired."

Electric Motors in Steel Mills



S. S. WALES.

SAMUEL S. WALES, electrical engineer of the Carnegie Steel Co., concisely cited the steps leading up to the present wide-spread use of electric power in steel mills and the conditions now existing which require its adoption. Reviewing the problem of continuity of operation in the first stages of electric power application the author said:

"Realizing the impossibility of absolutely continuous operation, the important consideration was to reduce the time lost by failure to a minimum. To accomplish this, it was very early discovered that the motors should be so constructed that the damaged parts, or the entire motor, could be readily replaced and no repairs attempted in the mill, and very careful attention to details was required to reach the present high standard which makes the modern mill motor the most convenient and dependable tool ever placed at the disposal of the engineer, as it is to-day."

"At the blast furnace, electric power is now almost exclusively used in new construction, and is replacing steam and hydraulic power in existing plants, wherever the changes required are not so radical as to make the first cost prohibitive. The automatic skip hoist, the ore bridge and transfer cars are all so familiar as to need no description. In the steel producing departments, cranes, charging machines, transfer cars, etc., are too common to attract notice, though some of the later applications, where the electric motor has replaced the hydraulic cylinder, such as ingot stripping, lifting furnace doors and tipping metal mixers and tilting furnaces, may still be of interest. It is in the rolling mill, however, where the ruling spirit is mechanical power rather than metallurgical reactions, that the electric developments have naturally been most spectacular.

"The electric motor has been applied to every class of machinery used in the production and finishing of steel, although only very recently has any one plant used electric power throughout. It would appear that the electric motor has proved itself to be wholly reliable, extremely adaptable, not excessive in first cost, and very economical to operate, and there should be no question as to its general adoption."

"Your (members of the American Iron and Steel Institute) patriotic support of the government and your untiring, self-sacrificing efforts in assisting to prepare for and prosecute the war are well known. You are recognized as leaders in the humanitarian movements which are designed to improve the living conditions of your employees and to bring about a closer relation between capital and labor."

From the early beginnings on cranes and charging machines, the motor now drives everything, including the screw-downs and manipulator, applications which were long and stubbornly contested by the steam engine and the hydraulic cylinder. One of the later achievements of the electric motor is the direct operation of a large billet shear, abandoning the use of the usual heavy fly wheel and clutch, and starting the motor from rest for each cut. This shear has a maximum stroke of 8 inches and the entire apparatus reaches full speed while the shear knife is traveling $\frac{3}{4}$ of an inch." (An article on this subject appeared in the September issue of "The Blast Furnace and Steel Plant.")

Referring to the present difference of opinions in regard to the use of compound or shunt wound motors for main mill drives Mr. Wales said:

"It is somewhat difficult to reason out the advantage of the compound winding on a motor for this service. It appears doubtful if there is sufficient time when the ingot enters the rolls, and the shock is thrown back on the motor, for the compounding current to overcome the reluctance of the magnetic circuit of the machine so as to have any appreciable effect in cushioning the shock. It is quite apparent, however, that in later passes, after the piece is well in the rolls, and the motor is called upon for power and speed, that the compounding will come into full action with a consequent decrease in speed, and a reduction in the tonnage output of the mill. It must of course be thoroughly understood that this compound winding is entirely independent of the inter poles and the main pole-face windings, which are universally used by builders of large reversing motors for securing sparkless commutation by controlling the distribution and density of the magnet field of the motor."

In concluding his paper the author dealt with the cost of equipment and operation and touched briefly on recent installations.

Fifty Years of Iron and Steel



JOSEPH G. BUTLER, JR.

WITHOUT a question one of the most interesting papers, from a historical standpoint, ever read at an American Iron and Steel Institute meeting was presented by Joseph G. Butler, Jr., vice president of the

"It is as true to-day as it ever was that the civilization of a people may be told by their progress in the use of iron and steel, and I hope the time will never come when America will no longer lead all other nations in this respect. I hope also that the time will never come when men in our industry will show less public spirit or less patriotism than in the past. In the present crisis of our national life we need the high purpose and the unselfish devotion to country that our members have shown."

Brier Hill Steel Company, Youngstown, O., who has been associated with the iron and steel industry for 60 years. The speaker reviewed in detail the incidents concerning the introduction of the Bessemer process in this country, in which Robert Mushet was given credit as being the first to make Bessemer steel by recarburizing the iron after it had been blown in a converter. "The invention of the Bessemer process, or rather its perfection and development, is generally regarded as the longest single step in the march of progress that has brought the iron and steel industries to their present stage, but there are other discoveries that seem to me even more important. We cannot make steel without iron, and therefore of even more moment than this invention were such things as the discovery of the Lake Superior ore ranges, the invention of the furnace top, the use of coke and its economical manufacture, the development of high blast temperatures, and especially in view of its recent rapid adoption, the Siemens-Martin open hearth furnace."

Formerly the blast was heated by passing it through cast iron pipes, which method kept the foundries busy making repairs, and interfered with the continuity of operation. The temperature of the so-called hot blast, which was only warm in comparison with the present-day blast, was measured with strips of lead and zinc. Thus no closer regulation was possible than that between the melting points of lead and zinc. The Plazer hot blast stove was brought from England to this country in 1868, and it, together with the Whitwell stove, which was the first to employ the regenerative principle, was an important factor in increasing blast furnace production. A German, C. E. Detmold, first used furnace gas for heating the blast in this country about 1859. Due to the expense of installation this method was, however, not adopted very quickly.

"The old stack of those days, with its equipment, would be picturesque in the extreme, if it could be set up in the vicinity of a modern steel works. The stack was usually about 35 feet in height and built of masonry, lined on the inside with a poor quality of fire brick. It was square in section, on the outside, the bottom being about 24 feet each way and the top somewhat smaller, this depending on the opinion of the man who designed it. The stack was usually located against a bluff, the double purpose being to make construction cheaper by using the hill to reinforce one side and enable a patient mule to perform the functions of a skip hoist by dragging the ore to the top of the hill. A short bridge connected the stockhouse with the top and the material charged was wheeled from this point and dumped in at the open top.

Only one or two tuyeres were used, and these were often on the same side of the stack, next to the blowing engine. In front was the sand bed, into which the iron was run, and to one side the space reserved for

roasting the ores. No water cooling devices were used except at the tuyeres and the opening in front. It was a very small proposition compared with what we are used to at this time, but was, nevertheless, a source of general public interest and regarded with considerable awe by the uninitiated. I can recall the first furnace in our district whose builders had nerve to locate it away from a hill. They used a hoisting device in which a tank filled with water raised the platform on which two wheelbarrows loaded with ore had been placed. When the wheelbarrows were dumped they were wheeled back on the platform, the water was let out of the tank at the other end of the rope and they came down to be refilled.

The blowing engines were of the crudest type and had but little power. There was then no method of gauging the pressure accurately and this was one of the cares of the furnace boss. He was expected also to know when the furnace was ready to cast, the proper color of the iron, and a great many other things. As a rule he did know these things better than might be expected, and these old furnaces made good iron even if they did not make much of it."

In describing the introduction of coke as a blast furnace fuel Mr. Butler gave figures showing that in 1850 only four furnaces were using coke, in 1860 21 were reported using coke, and in 1880 the census reports enumerated 149 stacks blowing on that fuel. The most striking development in blast furnace fuel seems to have been its cost, however. The average selling price of coke in 1860 was \$1.79 per ton—some coke was sold in 1917 for \$15 per ton.

The author of the paper described in detail the development of the by-product coke industry, new sources of ore supply, improvements in mining and transportation, and the development of steel fabrication.

War Influence on Export Trade



EUGENE P. THOMAS.

EUGENE P. THOMAS, president of the U. S. Steel Products Company, New York, pointed out that foreign trade must in the future be regarded as being vitally necessary to the material well-being of the na-

"Foreign trade, instead of being merely a contributing factor, has become an indispensable element of our industrial prosperity. Henceforth, we must accustom ourselves to regard it as vitally necessary to our material well-being, no less than to our national safety. If we are to meet competitive nations in foreign markets on terms of equality, it will be necessary not only that we establish methods of mutual co-operation, but that our government aid and protect us at least as effectively as our competitors will be aided and protected by their respective governments."

tion. He outlined the methods by which Germany's steel production during the nineteenth century had become 40 per cent in excess of its total consumption and how the surplus thus created had been marketed in foreign countries without regard to immediate profit. In competing with the systematic sale of German steel a price less than the net cost of the manufacture in Germany plus transportation charges was frequently encountered. This being one of the results of the well-known German policy of "dumping," as a means of securing undisputed possession of a given market, and affording justification for the extensive expansion of capacity greater than normal demand requires.

Due emphasis was placed on the part which metallurgy is playing in promoting and prolonging the war. At the beginning of the war Germany secured by conquest nine-tenth of all the French deposits of iron ore and 95 out of 127 French blast furnaces which were in active operation in 1913. To substantiate the important role which metallurgy is playing in the world's conflict, Mr. Thomas quoted representatives of six important German industrial associations who addressed the imperial chancellor on May 20, 1915, saying, "if our production of iron and steel had not been doubled since last August, it would have been impossible to continue the war. As raw material for the manufacture of these immense quantities of iron and steel the ore of the Lorraine mines takes the place of continually increasing importance. If the production of this ore were interrupted the war would be as good as lost." Considering the after war situation in the United States he stated that the annual capacity of this country would be from 35,000,000 to 40,000,000 tons of finished steel leaving 8,000,000 to 12,000,000 tons to find export which would be from 30 per cent to 100 per cent more than the present abnormal steel exports largely due to war requirements.

"Whatever the distribution of the European ore supply, it may be confidently asserted that our capacity after the war will represent nearly, if not quite as much as that of all other steel producing countries combined. We shall thus be as urgently in need of foreign markets for our products as the Germans ever were. But there would seem to be no reason to apprehend the post-bellum 'glut' of steel which some pessimistic observers have prophesied, at least during the first few years after the advent of peace. The destruction which has followed in the track of war has been so thorough and widespread, the depletion of existing stocks so complete, and the suspension of antecedent enterprises so much the rule, as to preclude any doubt about the steel-making capacities of the world, being fully employed during the period of rehabilitation. In addition to all this, the regeneration of the shipbuilding industry in this country will continue to provide a tremendous outlet for steel, and the coming demand for structural shapes and collateral steel pro-

ducts may be partially gauged from the fact that building statistics show that new construction has been greatly curtailed, as a result of the war requirements. The same statement applies to Europe as a whole no less than to the more progressive section of other continents, and there can be little question that after the war the demand for steel will be sufficient to keep the industry on a stable basis for a considerable period."

Looking still in the more distant future the author of this paper predicts that the 10 years succeeding the conclusion of peace will see an era of railroad construction such as the world has never before witnessed, and that the opening of these railroads will create a demand for the utmost volume of manufacture in the service of an improved agriculture, of irrigation, of mining, of utilization of water power and of the processes of an expanded and diversified industry.

"But it should be recognized that our share of this process will be small or great in proportion as we are able to coordinate our vast and varied productiveness to a common end. The necessity of balancing imports and stabilizing exchange: the creation of an American merchant marine; the necessity of compensating the output of additional capacity by increase of exports, and the advisability of meeting the combination of our competitors in the foreign markets by the use of similar weapons, would seem to be among the rudimentary requirements of the situation. It is manifestly of the greatest importance, for example, that we maintain imports of necessities, such as manganese ore from Brazil, nitrates from the west coast of South America, pig tin from the Straits, wool, coffee, rubber and other commodities. These extensive and valuable imports must be balanced somehow, either by the maintenance of an export trade with these countries or in the familiar triangular fashion of equalizing them by exports to other countries which make the required payments to our creditors in goods of their own.

The speaker stated that if we are to meet competitors in foreign markets on terms of equality it will be necessary not only that methods of mutual cooperation are established, but that government aid and protection must at least be as effective as the protection offered by the governments of competitive nations.

The upbuilding of a strong merchant and shipping marine was strongly urged as only through this medium will the country be enabled to freight the products manufactured in the United States to foreign markets on a competitive basis.

"The present plans of the United States shipping board, involving the building of millions of tons of ocean-going steamers, are not of greater consequence to the future of the export and import trade of the United States than they are to the maintenance of the steel industry on that high plane of efficiency and

maximum output which it has reached during the past year. There has been afforded through the unexpected exigencies of this war, a hitherto undreamed of opportunity for governmental assistance in the upbuilding of a great merchant marine, as well as a striking illustration of the means by which American manufacturers can cooperate under government sanction and supervision for the supply of materials in enormous quantities. Idealized by the patriotism and loyalty which it has exemplified, we have had a close affiliation between the government and the great industrial activities of the country, the value of which in solving the special problems of the present, is of good augury for the service it may render in meeting the demands of the future."

Malleable Iron and Its Uses



HENRY F. POPE.

"Many manufacturers have for several years given serious scientific study to their product with wonderfully good results, so that from many of them malleable iron can now be obtained of uniform quality and of greatly increased tensile strength without any sacrifice of ductility; for one peculiar feature of malleable iron is that while the tensile strength increases, the elongation also increases. This is not true of any other commercial metal."

THE structural difference between American and European malleable iron, as well as its users and characteristics were described by Henry F. Pope, president of the National Malleable Castings Company, Cleveland, Ohio, in a paper presented by him. After annealing, American malleable iron in distinction to European shows a white fracture inasmuch as in the annealing process the carbon, which in the original casting was all combined, is separated out by decarbonization and is found as free carbon or graphite of non-crystalline form, deposited between the molecules of the iron. This form of carbon is called by Ledebuhr "temper carbon" to distinguish it from its other forms. The presence of a large amount of temper carbon gives the material its black appearance. Graphitization of the carbon is more easily controlled commercially than oxidation, therefore the "Black Heart" is the more reliable product.

Regarding the relative merits of malleable iron and steel castings the author said:

"In most cases if the steel could be produced in the form and section of the malleable casting, it would be more expensive and no better; for it must be remembered that while the tensile strength of malleable iron is somewhat below that of soft steel, its elastic limit is just as high, which means that it will stand just as much

punishment as the steel. Furthermore, it is easier and cheaper to produce many articles in malleable iron. The iron is fluid at a much lower temperature than steel. To procure steel as fluid as the iron costs more; and when the fluid steel, at a high temperature, is poured into the mold, much more difficulty and expense is encountered than with the cooler iron. The problems of the foundry are comparatively simple in the case of the iron."

He furthermore deplored the fact that due to the lack of some manufacturers to conform with the best standards much discredit had been brought upon the industry in general. The many uses and applications of malleable iron were enumerated by the author.

Enrique Touceda, in discussing this paper predicted that in its field malleable castings would always occupy a place in exclusion to other castings and that its uses would be greatly extended in the future.

The possibilities of malleable iron were demonstrated by Frank J. Lanahan, when he gave figures showing that in certain samples, when the proper kind of raw material had been secured, 60,000 to 65,000 tensile strength with an elongation of $9\frac{1}{2}$ per cent to $17\frac{1}{2}$ per cent was attained in tests. The average results of one firm over a period of twelve months were given as being:

51,000 lbs. per sq. in.	ultimate strength
13 per cent	elongation
18.5 per cent	reduction in area

The maximum of these tests was approximately 57,000 pounds per square inch ultimate, 27.3 per cent elongation and 13 per cent reduction.

F. E. Nulsen in addition emphasized the property of malleable iron to resist wear.

Iron and Steel Scrap



W. VERNON PHILLIPS.

THE importance of the iron and steel scrap business was set forth in a paper delivered by W. Vernon Phillips, of F. R. Phillips & Sons Co., Philadelphia. "The total consumption of iron and steel scrap in the year 1916, over and above that made by the consumer, was in excess of 12,000,000 tons, exclusive of cast iron scrap and material used for chemical and other unusual purposes, also exclusive of the large tonnage of borings

and turnings used on the blast furnaces, all of which would make an additional 2 to 5 million tons, but we are without figures, or the present opportunity to secure figures, on this tonnage so we will confine our consideration for the present to the 12,114,000 tons consumed in 1916, which represents 9,646,617 tons of iron and steel scrap melted in open-hearth basic and acid furnaces including a small tonnage which was used in electric furnaces. Of the balance, approximately 2,000,000 tons was worked in rolling mills by the various methods employed, namely, busheling, puddling, piling and direct rolling into bar iron and soft steel, while over 600,000 tons was converted by mills rolling axles, shafting, etc., rolled to steel bars."

In speaking of the sources of supply for scrap authoritative figures estimate that 25 per cent of all the iron and steel scrap is produced by the railroads, 40 per cent by the industrial plants in the form of new crop ends etc., the other 35 per cent being shipped by scrap yards.

The value of iron and steel scrap according to Mr. Phillips, is in exact proportion to the value of the material it replaces, it having no manufacturing cost basis.

Regarding the need of the dealer in scrap Mr. Phillips said: "You are all either consumers or producers of scrap. There are millions of producers and hundreds of consumers who are served by thousands of dealers who are in turn served. The hundreds have always used this great advantage to discourage and discredit the thousands by the very simple and though probably innocent expedient of buying something they want but something the dealer can not always deliver. This is at the root of all the so-called dishonesty in the scrap business. In normal time the competition is very severe and the scrap dealers go beyond their own powers in their effort to please the buyer. Scrap is not produced, it is a by-product or a discard of something and it can rarely conform to specifications calling for strict sizes, weights, shapes and characters, especially under existing circumstances, when the stock piles of the country have been depleted, with labor scarce and unwilling, and with shipping facilities so limited. The greatest good a buyer can do to-day is to buy what the dealer or producer has to sell, rather than to buy something which he has to try to get out and get. Scrap has no value without a demand. For instance, when I was in the tin plate manufacturing business about twenty years ago, we were always at a loss to know what to do with our tin plate clippings or what is known as tin snap, and we paid money to have it hauled to the dump. Within a few years, Dr. Goldschmidt discovered a method of detinning, producing chloride of tin and oxide of tin and removing 97 per cent of the metal, leaving the residue of steel sufficiently free from tin to be used in the open hearth furnace, the black sheet trimmings left being hydraulically compressed. The detinning business has greatly expanded; tin scrap became a commodity and ever since has had a market value."

"I speak for the American Board of Scrap Dealers in asking the heartiest co-operation of all the consumers. Do not reject unless you have to. Do not reject for technicalities. Do not reject because the price has declined, but when you find what is known as a doctored car do not take it under any circumstances, and if possible, do not let anybody else take it; have it returned to the shipper and report him to the bureau. There are men in the business who give it a bad name and this is a good time to get rid of all bad men."

Gears and Pinions for Steel Mill Service

Tool Steel Process Described—Dissimilar from Case Hardening in That Entirely Different Ingredients are Used in the Carbonizing Process Giving Deeper and More Uniform Penetration.

By E. S. SAWTELLE.

It is somewhat embarrassing for me to handle the subject assigned without rather frequently making references to a trade name or a specific class of gear covered by the data given, and which is called by a trade name of "tool steel." There is no general name which will properly classify this particular article, though for obvious reasons I shall refer to it usually as the hardened gear. It must be borne in mind, however, that there are various methods of hardening gears and pinions, and the advantages or disadvantages of one method will not apply to another.

The material covered in this discussion is treated by a special process which for purposes of comparison must be likened to case hardening, though in the results obtained it differs radically from case hardened gearing. The likeness consists in the fact that both materials are made from a low carbon steel, preferably about .20 per cent, that they are subjected after manufacture to a carbonizing process which changes the chemical content and after this they are heat treated and quenched for hard-

ening. The dissimilarity lies in the fact that entirely different ingredients are used in the carbonizing process, giving a much deeper and more uniform penetration, a material which is free from virtually all of the defects and hindrances common to the ordinary case hardened gear. Whereas in case hardening, it is usually impractical to penetrate to any considerable depth, with this particular method a depth of as much as 3-16 in to $\frac{1}{4}$ in. can be readily obtained. Through-

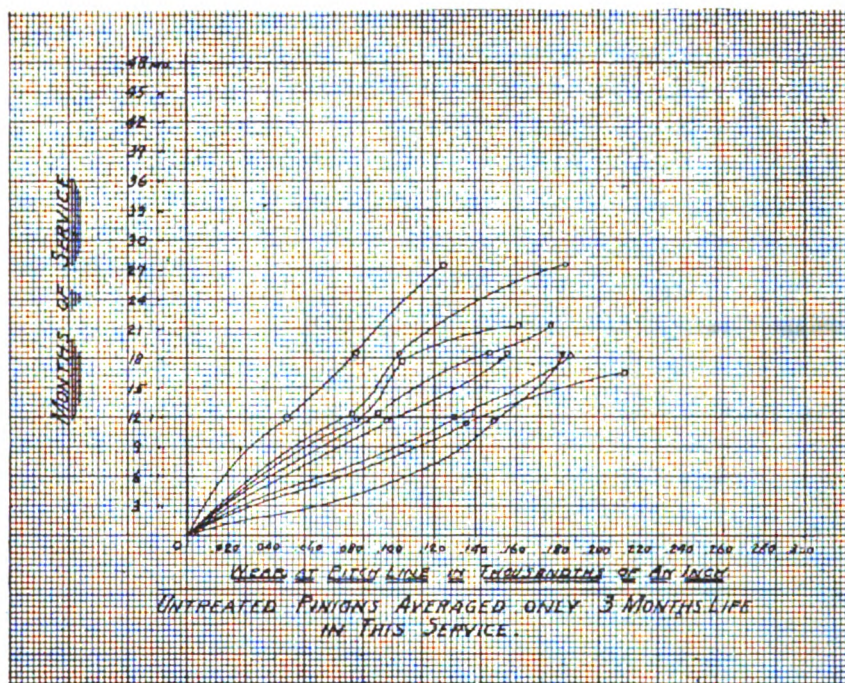
out this depth the hardness is virtually uniform instead of tapering off from a very hard skin on the surface to the soft center as in case hardening. This is particularly noticeable owing to the fact that the wearing qualities are maintained until the complete depth of hardness has been worn off, instead of having an acceleration in wear after a surface skin has been penetrated. The hardened wearing surfaces are particularly free from some of the most embarrassing case hardening difficulties, such as peeling, scaling, etc.

It is quite evident that most of the differences described are more or less intangible when it comes to an inspection of samples, but they have been very readily demonstrated in careful service tests covering a period of approximately 10 years. This feature is best illustrated by the fact that this particular grade of material is being successfully used in such service as crane track wheels, where to the best of my knowledge no one has had the temerity to even offer a case hardened part.

Obviously for gear service a composition with a glass-hard wearing face and a soft and tough center is ideal, and gives much better wear and strength than anything obtainable by the use of a homogeneous steel, heat treated or quenched for toughness and hardness, but where neither of these can be obtained at their maximum since the hardening tends to brittleness, and the toughening tends to softness.

Methods of Manufacture.

The general method of manufacture is, first to machine the part throughout, then raise the carbon con-



Curve showing uniformity of wear.

Paper presented at the Eleventh Annual Convention of the Association of Iron and Steel Electrical Engineers, Philadelphia, Pa., September, 1917.

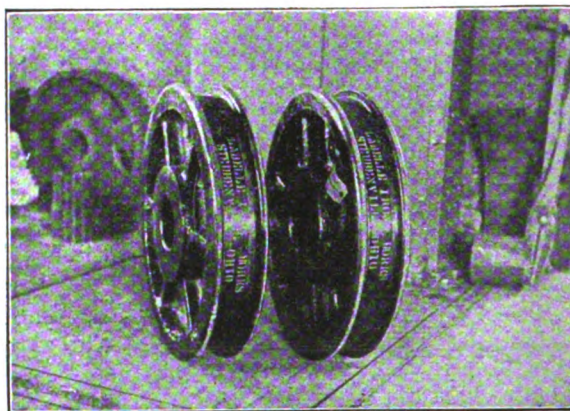
tent for the desired depth to approximately 1 per cent, protecting the bores so that they retain their original chemical properties. A series of heat treatments refines the grain and hardens the piece, at the same time very decidedly toughening the center. While it is possible to protect the bore, or virtually any surface where a junction of steel on steel perfectly tight can be obtained, it is practically impossible to do selective hardening by protecting certain parts with special paints, copper plating, or similar methods. The penetrating qualities of the carbonizing agent are such that these methods common to case hardening, are absolutely non-effective. A certain amount of selective hardening can be done at decidedly increased expense by leaving the parts large, raising the carbon content to an equivalent of tool steel, annealing, and then turning off the piece in the parts to be left soft until the high carbon material has been completely removed. After this operation has been completed the piece is hardened by quenching and heat treatment; the surfaces that have been machined after the impregnation process will remain soft.

As has already been stated the center of the gear remains of the same analysis as the initial material which is approximately .20 per cent carbon steel. This steel responds somewhat to the proper kind of heat treatment and when backed up on either side by a hard and more or less rigid substance, gives unusual strength. The wearing surface will run from .90 per cent to 1.20 per cent in combined carbon, and as such, is entirely similar to high grade carbon tool steel, such as was used for

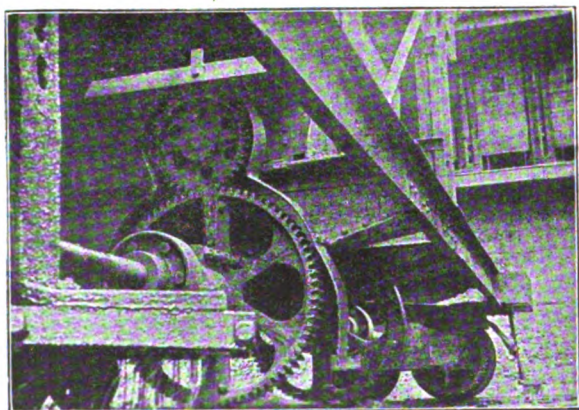
Exact physical properties are unobtainable owing to the two-fold nature of the material, which does not lend itself to reliable physical tests. Obviously a test of the center would not be characteristic of a test of the piece. In actual gear service tests, it has been



Citizens Gas Company, Indianapolis, coke charging crane—In such service the gear lubricant is continually full of coke dust.



Typical crane track wheels.



Hardened driving gear on coke charging crane. They are wearing one-fifth as fast as untreated gears on the opposite drive.

lathe tools prior to the advent of high speed steel and is now being used extensively on drills, etc. This method of hardening is being used to some extent for tool work, especially for taper reamers, and as such is giving life fully as good as from carbon tool steel.

demonstrated that the combination of the two hard surfaces with considerable rigidity backing up the very tough center gives a tooth that has greater strength and greater resistance to shock and strain than does the high carbon untreated gear or the gear of homogeneous steel that has been quenched for toughness. The hardness of the outside wearing surface will run from 90 to 100 on the scleroscope and is too great for accurate test on the Brinell instrument. A sharp corner can be used to scratch glass without difficulty. In connection with the subject of physical properties, it must be borne in mind that the only true criterion is to test out the actual piece itself rather than a small test bar which may be prepared in a way somewhat or exactly similar. I believe that the latter method is very deceptive since the internal heat in the test bar is very small, whereas in the gear it is much greater and tends to retard the cooling and to give properties that are quite different from properties that can be obtained from the small piece responding immediately to the action of the heat or quenching agent. Very frequently astonishingly good physical properties can be obtained by a heat treatment of the small test piece, but they are not comparable with the properties obtained when a large piece of steel is handled in the same manner. For these reasons, we consider that the only fair durability test is on actual service.

Inasmuch as the gears are machined before they are subjected to the hardening process, it is essential that precautions be taken to have them correctly designed so as to avoid distortion. It takes years of

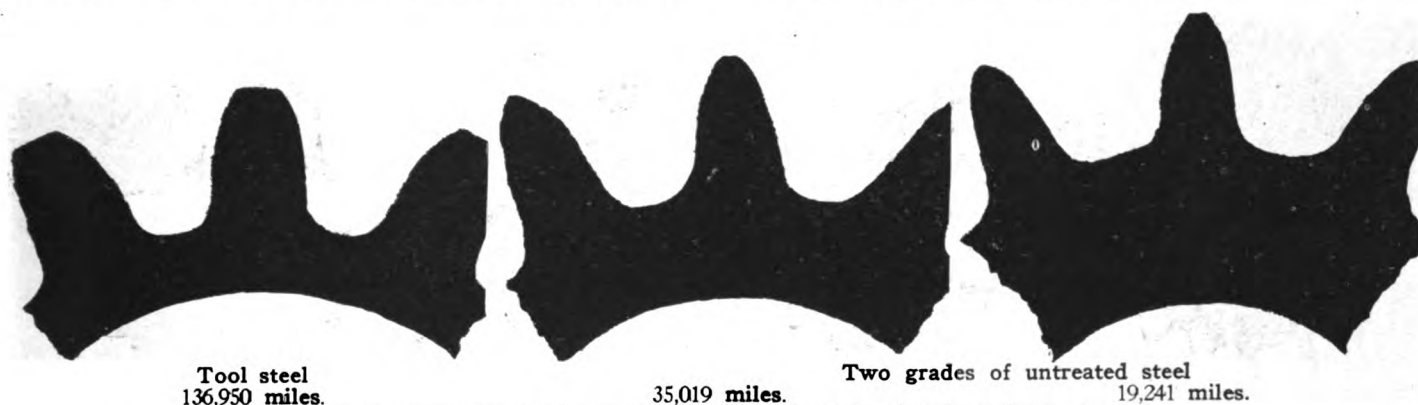
experience to know the proper way to handle gears, keeping them true to their original shape. Despite all the theoretical calculations on the subject of distortion, it resolves itself down very largely to a matter of past experience applied to the individual cases at hand.

Distortion is nearly always encountered in the nature of shrinkage, running usually about 1-64 in. shrinkage for each foot in the diameter. This, however, depends considerably upon the pattern and design, since if these are not properly balanced and established, there may be a great deal more shrinkage and a decided distortion in addition. Very frequently pieces must be tempered in specially designed jigs to keep them straight. In a gear running from 24 in. to 50 in. in diameter, properly handled there should be very little distortion out of plane, not running more than about 1-32 in. to 1-16 in. at the most. When the decrease in diameter through shrinkage is balanced up and figured on the basis of radius instead of diameter, it is too small for any practical concern in the average run of mill or electric railway motor car gear-

tor gears which will operate at a peripheral speed of as high as 4,000 feet per minute, and yet these gears are quiet in their operation. The test in electric railway service is unusually severe as the least indication of excessive noise causes severe criticism. In careful tests on both machine molded cast-tooth and on cut-tooth spur gears up to six feet in diameter, the distortion is found to run so slight as to be detected only with delicate calipering instruments. In hardening mill pinions up to 10 feet in over-all length we have found that the distortion is almost negligible excepting that a slightly greater allowance must be left for grinding the bearing surfaces.

Intermating Hard and Soft Gearing.

The question as to the desirability of running hardened pinions with soft gears, or vice versa, is one of considerable importance and one that has been carefully checked in numerous tests. These tests have indicated that it is wholly unwise to run the hardened steel pinions with cast iron mates; that it is not advisable to intermate the hardened steel pinion



The above impressions show three pinions in electric railway test.

ing. Pinions are frequently made as a unit with some shaft, such as is the case in the typical mill pinions, or in some cases armature pinions, too small to be detached from the shaft. In a case of this sort there is apt to be a certain amount of kinking or distortion in the shaft, especially if it is long; this can be corrected by making it oversize and grinding after the hardening operation. Inasmuch as the shaft has a soft, tough, pliable center, it is possible to straighten it cold within reasonable limits before the grinding operation.

The natural tendency is for distortion to cause noisiness and excessive vibration, but we have found by experience that this can be kept down so that it causes no annoyance in installations where the speed is excessive. In one case, a continuous rod mill is operated through gears of 18 in. pitch diameters at 1,123 r.p.m., giving peripheral speed of approximately 5,292 feet per minute. Another rod mill with gears of 20 in. pitch diameters operating at 955 r.p.m., gives a peripheral speed of 5,000 feet. We have numerous cases of 28 in. and 29 in. diameter electric railway mo-

tor gears. It is, however, good practice and entirely proper to intermate the hardened pinion with a gear where the carbon content runs higher than .30 per cent, the higher the carbon the better the combination. In case the hardened pinion is run with the untreated steel gear, experience has shown that the combination is always detrimental to the fullest service of the pinion. Whereas a hardened pinion mated under the same conditions with a hardened gear will last from seven to 10 times as long as the ordinary untreated .35 per cent carbon steel pinion, if it is mated with a soft gear, it will only last from four to six times as long as the .35 per cent carbon pinion. The effect upon the gear is generally conceded to be good, owing to the fact that the hardened pinion retains its full tooth shape and contour for a very long period of time and takes on a high polish, which tends to curtail friction and reduce the gear wear.

It is, however, considered by far the best practice wherever possible to mate hardened pinions with hardened gears.

General Advantages.

The primary advantage in using the hardened gear is the long life. Service tests have demonstrated its ability to wear from seven to 10 times as long as the ordinary untreated gear and at least twice as long as any other grade of special such as case hardened, heat treated, manganese steel, mold hardened, etc. Coupled with the long life is a decided saving in installation cost where a hardened gear once installed will avoid numerous replacements, with incidental saving in freight and storeroom charges. Loss of output is no small consideration in this connection. As an illustration, we know of several steel mills where their cost for the installation of a \$10 pinion runs into hundreds of dollars unless the change can be made on one or two national holidays when the plant is shut down. This loss is not in the nature of direct labor, but because of reduced output.

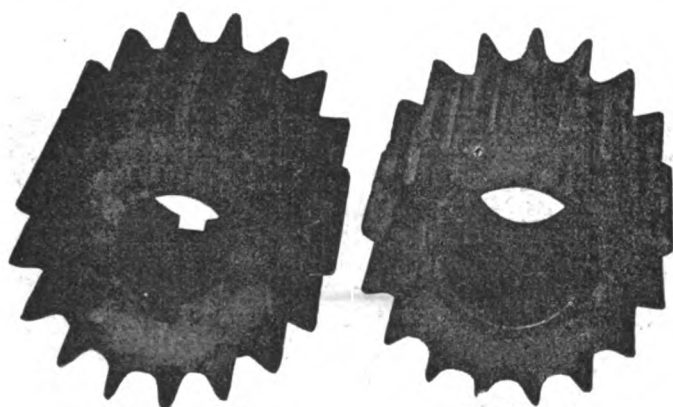
It is frequently the case that one or two gears are the limiting factor in a machine; the only solution is to increase the size of the gears or to improve the

condition applies either to pattern cast gears with cast teeth or to gears with cast teeth, formed by machine molding. In either case it is always desirable to slightly clean up the teeth after the casting operation.

Specific Instances.

It is exceedingly difficult to keep accurate records in mill operation and get close comparisons to show quality in gearing. As a rule the severest service in any particular place is selected for a test. We are citing a number of cases of this sort showing the results obtained, doing this with the thought that these instances may offer suggestions of specific places where the hardened gear will prove of advantage in other mills or services.

In electric railway motor car service both wear and strength are absolutely essential factors, owing to the continual increase in the horsepower of the

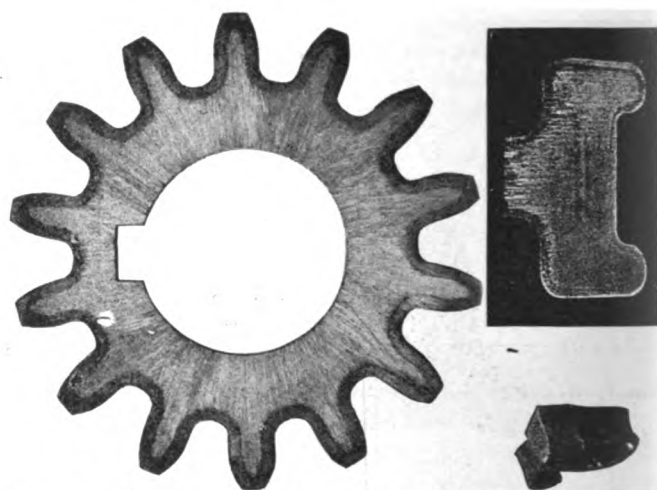


Oil tempered Tool steel
Tool steel and oil tempered pinions tested on the same car, electric railway service—The tool steel pinion gave 62,679 miles and the oil tempered 14,667 miles.

quality: The former is usually a very expensive remedy since size increase in gears must be accompanied by corresponding increases in housing, bearings, etc. In such cases, the hardened gear proves of tremendous usefulness. In designing new machines, the size of the gears can be greatly reduced and thereby their cost cut down by the substituting of a long-lived, high-quality, high-strength hardened gear in place of the ordinary untreated material.

It is a decided advantage to have the hardened gears so protected on the bores and keyseats that they can be machined to an exact fit before application, and even if necessary, have this machining operation done in the customer's shop to fit non-standard shafts.

In cast tooth gears, it is possible to make accurate and uniform teeth in low carbon castings, so the gears run quietly after hardening. It is further of decided advantage that before the hardening process the teeth are soft and any irregularities or bumps can be readily filed or machined after the casting is made. This con-



Sections of tool steel gear and track wheel showing depth and uniformity of hardness—The small illustration is a section of a motor pinion polished to show hardening on one end; hardened steel ground off sides of tooth and cold bent to show toughness.

motors which has not been accompanied by a corresponding increase in the size, pitch or face of the gears in this service, accurate tests are obtainable, as there are four motors under the car, and it is possible to equip part with special gears and part with ordinary grades and check the relative life. This has therefore been a field where virtually every quality of gear has been tried out; untreated, oil and water quenched, and case hardened. In this service gears with the tool steel wearing surface have invariably proven their superiority on a basis which entirely eliminated the untreated gear from the calculations and which has outstripped the various special gears in ratios of from two or four to one. Kindred to the electric railway field are the motor gears for coal mining locomotives and machines and the mill motor gears and pinions. These types of gearing are almost invariably cut-tooth and of comparatively fine pitch. Gears in the cement mills, steel mills and foundries operate in unusually dirty and dusty atmosphere which greatly accelerates

wear. A test was followed in cement mill service where the ordinary untreated pinion lasted eight months; the hardened pinion in this service has now been in use slightly less than three years and shows about one-third as much wear as is normally allowed. In a steel mill ladle crane test, in a particularly troublesome location, ordinary pinions had been lasting four and one-half months; a heat-treated, oil-quenched pinion was installed which lasted $11\frac{3}{4}$ months. After this a hardened pinion was applied, and it was in service 32 months, and when removed was not entirely worn out.

Rod mill pinions, operating at exceedingly high speeds, are normally subject to considerable breakage, especially after the pinions become worn. We have several cases where the application of the hardened gear to this service has eliminated wear, kept the machinery in smooth operation and absolutely without breakage, though the tests have run from two to three times as long as the life usually obtained from ordinary pinions.

A test was followed in blooming mill screw down service, where the untreated motor pinions average only two months' life, due to excessive wear. The hardened pinion is still in service, after over one year's use, and is now about half worn out.

Cast-tooth table miters are usually worn out rapidly and the ones next to the rolls are subject to breakage strains. Tests in this service have been run in numerous mills comparing with untreated, mold-hardened, and manganese steel. In comparison with untreated gears, the hardened ones have now lasted twice as long, and show barely a polish on the teeth. As compared with mold hardened, experience has shown about a three to one ratio of life, and about $2\frac{1}{2}$ to 1 in comparison with manganese. Compared especially with teeth unmachineable after casting, gears with tool steel wearing surface are much more satisfactory, by reason of tooth smoothness with reduction in vibration and noise. Hardened gears have demonstrated themselves to be proof against breakage due to the toughness of center of teeth. A number of steel mills are now standardizing on hardened material for their staggered tooth spur mill pinions, basing these decisions upon long life and strength in the pieces, and upon the fact that the wobblers can be accurately machined and then hardened to reduce excessive wear and play. In one case tests are now being run on hardening the coupling box as well as the wobblers.

Because of the grittiness of coke dust, there is a considerable field for hardened gears in coke machinery. A hardened cast tooth shrouded spur rack pinion on a bee-hive oven coke drawing machine, drew 9,000 ovens of coke after which it was worn about one-third as much as allowable. The untreated steel pinions in this service average 2,870 ovens when completely worn out. Grit and dust are decided factors in gear

wear on crane service, especially in foundries.

Tool steel wearing face is found desirable for certain other classes of work, such as on track wheels and sintering chains. In the track wheels, the hardened wearing surface is a protection against rapid tread wear and is especially valuable for prolonging flange life if rails are not in perfect alignment. Poorly lined rails will frequently cut out the softer steel wheel, or cause the flange to peen out of shape or to break. Breakage in the tool steel wheel is obviated by the toughened center of the flange. While track tests have not been followed on as extensive a scale as gears and pinions, a number of the large mills have now reached the point where they are continually sending repeat orders, and in one case the hardened wheels have been in service $5\frac{1}{2}$ years as compared with 8 months, the average life obtained from cast steel wheels. Wherever it is possible to obtain forged material, the track wheels are made from forged or rolled steel blanks, or from solid forgings.

Very exhaustive tests have been made in one of the large sintering plants leading to their standardizing on hardening chain. In this particular service 1-in. chain is used in endless sections 240 feet long, and is continually circulated through sintering kilns carrying scrapers to keep the sides of the kiln clean and stir and break up the iron to be reclaimed. The temperature of the kiln is very high and would ordinarily draw the temper of the hardened chain, but this is obviated as the chain moves through in less than a minute and is for a corresponding time submerged in a bath of cold water on the outside. In this service, numerous grades of chain were tried, the best of which lasted from six to 10 days. Removal was due to excessive wear and frequently breakage on the part of the worn links. Hardened chain has lasted from 92 to 100 days, and thus far has given no breakage trouble excepting in one or two cases, where defective welds in the links have been opened up. In this service the hardened chain has been successfully used for over a year.

Sintering chains are not subjected to excessive strains and while hardened chain can be satisfactorily used in this field, it cannot be recommended for service where there is not a large factor of safety against breakage. This is due to the fact that in chain the strain is entirely a tensile pull and the hardening reduces the strength. On the other hand, gearing is subjected to a compression rather than a tensile test.

The mill industries, especially in the gearing fields, continually offer problems that are baffling. There is an increasing tendency to solve these permanently by the use of the highest quality. There is probably no other field where economies are greater and the elimination of annoyances more noticeable than where quality gears are used to solve gearing troubles.

Smelting Pig Iron in the Electric Furnace

Shell Turnings Used as Charge—Charcoal, Coke or Coal for Carbon Base—Power Shortage Offers Chief Obstacle—Opportunity for Cheaper Production of Low Phosphorus Pig Iron.

By ROBERT TURNBULL,
Electric Furnace Engineer.

The abnormal high prices which are at present being paid for iron and steel products, and which have been ruling for the last eighteen months, have seemingly failed to stimulate or encourage the manufacture of pig iron from ore in the electric furnace. Although from \$50 to \$80 per ton is now being paid for the different grades of pig iron, no progress has been made in the United States or Canada in the production of electric pig iron from ore, and it may safely be said that outside of Sweden and Norway the production of pig iron from ore in the electric furnace is practically nil. That pig iron could be made from ore in the electric furnace under present conditions, and at the same time yield a handsome profit, there is not the slightest doubt, but there are many difficulties in the way of the prospective manufacturer and one of the most serious is the shortage of power.

In the early part of 1906, when the smelting of pig iron in the electric furnace was undertaken by the Canadian Government, the report issued some time afterwards claimed that the results of the experiments had proved that 4 tons of pig iron could be produced per horsepower-year; in other words, this amount of iron could be produced with an expenditure of about 1650 kw.-hr., whereas the present Swedish practice, where large furnaces are used, shows that from 2500 to 3000 kw.-hr. is required to produce one gross ton of gray iron.

A few years ago the writer made some experiments with a single-phase furnace using about 650 kw., the ore used being a hematite containing from 50 to 52 per cent metallic iron. This furnace was operated for several weeks and the expenditure of energy per gross ton of pig iron produced was 2300 to 2400 kw.-hr. It will therefore readily be seen that to produce any considerable quantity of iron in the electric furnace large amounts of power will be necessary, and this, coupled with the fact that such an enterprise could only be operated under existing conditions, which are liable to change at any moment, has no doubt deterred investors from risking the capital necessary for such an undertaking.

The writer's own experience has not gone to show that any advantage has been gained either by lowering the expenditure of power or decreasing the gross cost of the product by the use of the shaft furnace, such as

is used in Sweden, for unless the gases are utilized the shaft furnace becomes a complicated, expensive and unnecessary piece of apparatus. A well-designed ordinary electric smelting furnace with partial roof and automatic charging from overhead hoppers will produce a cheaper pig than the shaft furnace, and the first cost of plant would be considerably less.

With the war, however, a new industry has been created for the electric furnace, which owing to its practically low initial cost in plant and low power consumption, bids fair to become very popular, and that is the production of pig iron from shell turnings and shell scrap.

As the specifications for steel to be used in the manufacture of shells call for low phosphorus and sulphur, it is possible in the electric furnace to produce a low phosphorus pig iron from such scrap at a figure which, given the present selling price of low phosphorus pig iron, yields a handsome profit, while very little refining is necessary. Any type of steel furnace can be used for this process, and it is not even necessary to have a furnace of the tilting type when little refining has to be done, as by special manipulation of the slag in the furnace, a certain amount of phosphorus can be removed, and sulphur is always to some extent eliminated by the basic slag employed.

The possibility of this process was first brought to the writer's attention in the fall of 1916, and experiments were immediately undertaken in a small furnace at Orillia, Ontario. These experiments having proved the process to be a feasible one, a new single-phase furnace was built and has been in successful operation since January of the present year. From 6 to 7 tons of low phosphorus pig iron is being produced per twenty-four hours, the amount of power used on the furnace being about 250 kw.

Furnaces for this work have since been installed at St. Catharines, and Collingwood, Ontario, also at Shawinigan Falls, Quebec, and a number of furnaces are now operating in the United States.

At St. Catharines the furnace is of 6-ton capacity, three-phase operated by Packard transformers of 1200 kw., but only 700 kw. is being used at the present time, owing to the shortage of power. The daily output is around 20 tons. It is estimated that the production will attain 35 gross tons with the full power of 1200 kw. The operation is in many respects similar to the making of steel in the electric furnace, the refining pro-

Paper read at the convention of the American Electrochemical Society, Pittsburgh, October, 1917.

cess for the elimination of phosphorus being somewhat different. The charge consists of shell turnings, the necessary carbon base, which may be charcoal, coke or coal, ferrosilicon and lime. Manganese is not added, as care is taken in the process to conserve the managanese already contained in the turnings. The furnace is of the fixed type, with a carbon bottom and silica brick lining; there are two charging doors and one tap hole, similar to what is used in open hearth furnaces. The furnace is controlled by automatic regulators, which eliminate to a great extent manual labor on the furnace, besides giving a much steadier load than is possibly by hand control. The product is cast in sand, the pig beds being placed about 30 ft. from the furnace. In our Orillia plant the iron is cast into iron molds, which make a better looking pig than sand casting. The return in iron as compared with the scrap charged is about 95 per cent, and as about 5 per cent is added to the iron in the form of carbon and silicon, the total loss is about 10 per cent of scrap charged. The pig produced is very tough and the analysis is fairly uniform, as can be judged by the following table of consecutive heats:

Heat No.	Silicon	Sulphur	Phosphorus
237	1.45	0.025	0.025
238	1.83	0.029	0.031
239	2.82	0.030	0.033
240	2.11	0.029	0.027
241	1.88	0.025	0.027
242	2.49	0.027	0.027
243	1.21	0.035	0.040
244	2.35	0.030	0.030
245	1.25	0.029	0.031
246	1.55	0.027	0.027
247	1.59	0.028	0.031
248	1.50	0.025	0.029

The carbon is very rarely over 3 per cent; from this point onward any extra carbon added is very destructive to the lining and roof of the furnace. A roof will last from 150 to 200 heats; the roof conditions are being gradually improved and 300 heats may yet be realized for one roof.

The process is not a new one, as attempts were made several years ago to make pig iron from scrap steel, but the cost was found to be prohibitive. The writer also made some experiments in operating the pig-iron furnace for ore, before mentioned, by mixing 50 per cent each of scrap and ore in the charge. The result was an increased production from about 6 tons on ore alone to 11 tons with the mixture. The same amount of power was used in both cases.

In passing, it might be said that some of the blast furnaces in the States are now mixing considerable quantities of steel turnings with the ore, in order to increase their output.

Whether this process will be feasible after the war and when normal conditions are again with us is not a settled point. The cost of production is at present high, and would be prohibitive under normal conditions. It must be remembered, however, that costs to-day are possibly 50 per cent higher than they were three years ago, and it is the writer's conviction that provided future experiments find a means of eliminating phosphorus from the iron without removing the slag, the process can be profitably operated in normal times, at least in Canada, where low phosphorus pig iron is always a dollar or two higher than in the United States.

By-Product Coke Oven Pressure Regulation

Adjustment of Valve Opening to Correct for Variations of Ex-hauster Suction More Important Than Correcting Variations in Gas Volume—Stabilizing Feature Improves Regulation.

By C. H. SMOOT,
Vice President Rateau Battu Smoot Company.

In the October issue of The Blast Furnace and Steel Plant, the discussion of coke oven regulators by Prof. Trinks and Mr. Frederick W. Ells brings out several pertinent points. Prof. Trinks shows very clearly by his mathematical discussion, as illustrated by the diagram of Figure 3, the characteristics of the type of regulator to which he refers. We cannot but agree with Prof. Trinks' conclusion regarding the regulator under discussion.

With reference to Mr. Ellis' discussion, it does not appear that Prof. Trinks' contentions have been refuted. Mr. Ells shows, however, that under certain conditions—perhaps well explained by Prof. Trinks in his reply as conditions requiring little regulation—the type under

discussion gives practical results. On the other hand, under other conditions as close regulation as illustrated by Mr. Ells' pressure chart is known to be difficult to obtain. Mr. Ells states that the speed of the valve is so selected that it does not over-run, but follows up at about the same rate as the average change in pressure, due to increased volume when a newly charged oven is put on. From this we infer that each installation is considered and the average rate of volume increase determines the speed of valve operation. This is a rather nice adjustment and indicates that necessity of very slow action to give good results with this type of valve.

It would appear to the writer that both Messrs. Trinks and Ells have overlooked the principal duty of

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the regulator, which lies not so much in correcting for variations in gas volume as in adjusting the valve opening to correct for variations of exhaustor suction. The pressure drop through the valve is subject to considerable variations arriving through imperfect regulation of the exhaustors. The suction on exhaustor side of the regulator is not constant and to correct for its variation would appear the more difficult part of the regulator's functions.

Referring to the article by Prof. Trinks, it appears that the regulator is called on to maintain 8 mm. vacuum within 2 mm. variation. In other words, the percentage of regulation demanded is 25 per cent. It appears to us that a regulator which cannot regulate within much less than 25 per cent is obviously susceptible of improvement. Speed regulators on engines, turbines and pressure regulators of steam and air have all been developed to a far greater degree of accuracy.

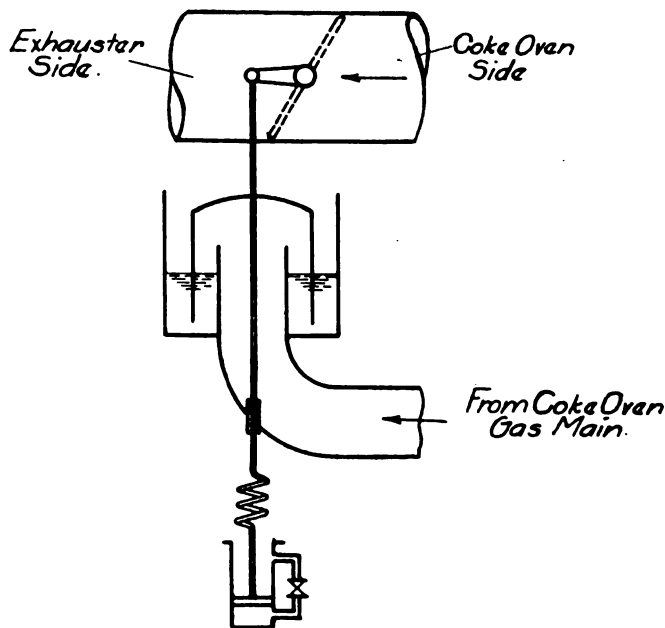


Fig. 1.—Diagrammatic illustration of theoretical governor.

In comparing these more accurate regulators it is interesting to note that nearly all have the following characteristics:

First.—The rate of opening or closing of the valve is not constant but varies with the demand for change. A small change in condition gives a small change in control valve opening; a large change in condition gives a large change in valve opening.

Second.—To insure stability of control these regulators have what is known as a regulation characteristic consisting of a small percentage difference in pressure between small load and large load, usually 3 per cent on engine and turbine speed governors, the difference in regulated pressure measuring the degree of stability.

Third.—A stable governor of this type can be constructed in which there is no difference in speed between no load and full load condition under steady load, but

a momentary pressure change is added during change of load to give stability under changing load conditions. This produces temporarily the second condition above and is usually accomplished by a dashpot connected through a spring to the regulator mechanism, the compression of the spring giving stability which when the load changes is later removed by the releasing action of the dashpot, allowing a constant load to coincide with the constant pressure for which the regulator is adjusted.

Fourth.—The regulators have a definite relation between valve position and position of the controlling element—in other words, to one position of the control element responsive to changes in condition, corresponds one position of the controlled valve.

In the regulator discussed by Prof. Trinks none of these characteristics are present.

1.—The rate of change in the valve opening is constant. The valve is either at rest, opening or closing, with a fixed rate of change.

2.—The regulator has no inherent stability, since it endeavors to regulate and maintain the same pressure on a wide open valve as is maintained on a closed valve.

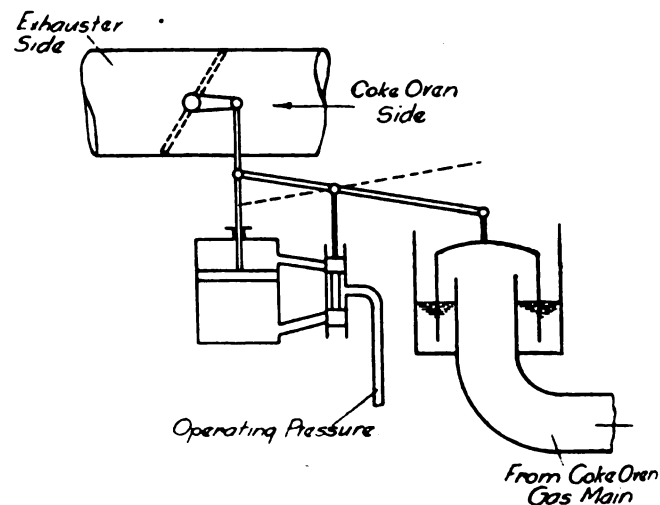


Fig. 2.—Diagram of relay governor.

(The stabilizing spring has been omitted from the sketch.)

3.—During the period of change of load and movement of valve there is added no temporary element of stability tending to prevent over-travel.

4.—There is no definite relation between controlling bell position and valve position.

Let us imagine a theoretical valve for the regulation of the gas which would contain all of the above characteristics for the close regulating stable regulators employed in other lines of work. Such a valve is illustrated in Figure 1 and has the following characteristics:—A.—A powerful control bell directly connected to the butterfly valve, regulating the gas flow with sufficient energy to make negligible any friction in the connections between bell and valve, thus giving for each position of the bell a definite position of the valve. B.—A spring loading on the bell arranged like the loading of an ordinary governor, so that when the bell moves from

its extreme lower to its extreme upper position the moving pressure must change 3 per cent; or in place of the spring loading the lower end of the spring may be attached to the moving element of a dashpot, thus adding the stabilizing action of the spring to the regulator only during periods of position change, but allowing the regulator on constant volume to give always a constant pressure. C.—The moving elements of the regulator are assumed to have no inertia, a condition necessary for this theoretical valve we wish to discuss.

Assuming such a regulator possible to construct, all of the conditions found present in a good operating regulator are present. Any increase in pressure causes an immediate opening of the valve by an amount corresponding to the pressure increase. For example; with the dashpot locked against motion, suppose the valve to be nearly closed and the suction of the gas at point to be regulated is 6 mm. of water. A sudden increase of this pressure to 7 mm. of water would cause a sudden opening of the valve to half full opening. A further

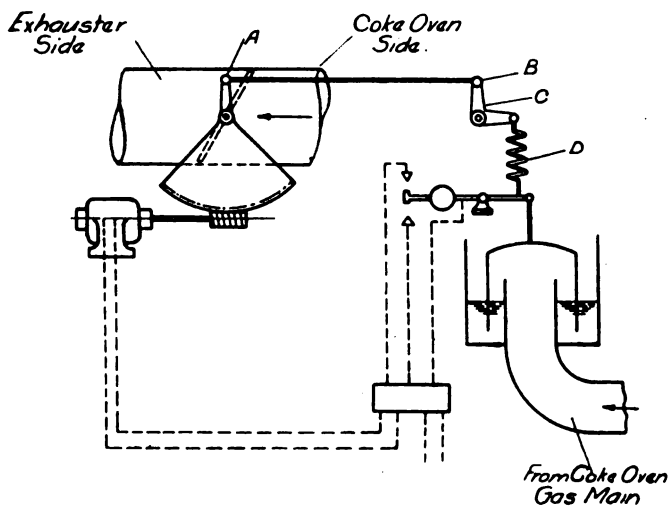


Fig. 3.—Diagram of governor with regulation.

increase of 1 mm. would open the valve wide. Thus the valve moves with the gas pressure, always having for each pressure within the regulated range a definite opening of the valve. With such a regulator close regulation could be obtained and there would be no tendency whatever to race or maintain continued oscillations, provided the assumptions above are fulfilled.

We can now extend this imaginary valve to one in which there is no inherent regulation. In other words, when adjusted for 6 mm. of gas suction the valve bell can be either in extreme upper or extreme lower position, this being done by releasing the dashpot piston. Such a regulator would race badly and give oscillations in pressure, were it not for the stabilizing dashpot and spring. Any tendency to race brings into play the spring between dashpot and valve, which spring requires an increase of gas pressure for an opening action on the valve, and during periods of regulator motion add to the apparatus the regulation characteristic of the spring obtained

in the first regulator above described, which regulator is automatically removed by the dashpot releasing after a new condition of constant pressure has been maintained.

This imaginary valve obviously cannot be constructed in the simple manner above described, since the actuating pressures are so very small that no real effort can be realized from them to move the valve; also the inertia of the bell and valve parts would be so great that a movement would occur very slowly and at a long time interval, after a change in pressure. This difficulty, however, might be overcome by still further applying the principles of engine regulators and interpose between bell and valve a sensitive relay, which will supply sufficient energy for moving the heavy valve parts. This element might take the form of a steam or oil operated cylinder connected to the valve and controlled by a small pilot valve connected in mid position to a compensating link running from valve to bell, or perhaps by the use of an electric motor. Such an arrangement is

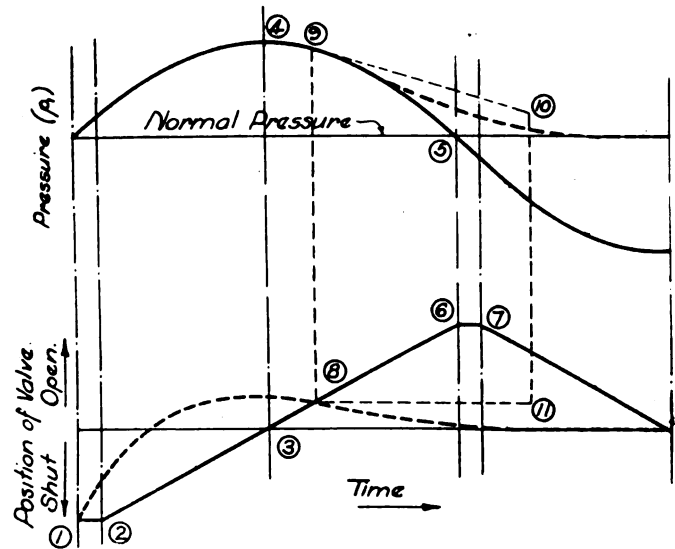


Fig. 4.—Fig. 3 of Prof. Trinks' article with dash curves added for comparison.

illustrated in Figure 2.

By these means a very light weight and sensitive bell of small energy, capable of responding freely to small pressures, is made to actuate a pilot valve, which in turn supplies a large amount of energy in the form of fluid pressure to the cylinder which actuates the gas valve. With this apparatus a gas regulator, which duplicates in all its essential characteristics the engine regulator, may be applied and by these means overcome the difficulties pointed out by Prof. Trinks.

Referring to Figure 3 of Prof. Trinks' article, it is obvious that the length of time during which the pressure remains above normal is entirely controlled by the speed of the valve opening. Where the valve made to open more rapidly for large departures from normal pressure, and vice versa, the time interval of excess pressure would be reduced. If in addition an element of stability were added to the regulator, the bell would have a definite pressure corresponding to the position of

the butterfly valve. A given change in pressure would cause the valve to open a definite amount and stop with a pressure above normal in the bell. The addition of such an element would reduce the tendency for oscillation, but would not overcome all of the difficulties encountered with the regulator, since its slow speed of valve action would of necessity remain. Such a stabilizing equipment is illustrated in Figure 3; herewith, which is a reproduction of Prof. Trinks' Figure 1, to which has been added stabilizing equipment as follows:—An arm is attached to the spindle of the butterfly valve and connected by the rod "AB" to a bell crank "C," which has connected to the other arm a spring "D," interposed between the bell crank and the controlling bell, subject to coke oven gas pressure. The stiffness of the spring "D" is such as to require a greater gas pressure under the bell for a wide open valve than is required for a closed valve. Similar regulation—producing equipment has been employed on other apparatus, such as the curve tracing electrical meters and certain hydraulic apparatus. This type of regulating-producing equipment, however, is best suited to regulators which operate slowly.

With this equipment on the regulator the diagram of Prof. Trinks would be appreciably altered and by proper selection of stabilizing spring stiffness it would be possible to have the opening action of the valve cease at some such point as "8." A continued opening of the valve is tending to depress the regulating bell through spring "D," which finally overcomes the excess pressure and breaks the electric contact, shutting down the motor. It will be obvious that by whatever extent the overtravel of the valve is reduced by the stabilizing spring "D," the stability of the regulator is improved.

In Figure 4 is reproduced the Figure 3 of Prof. Trinks, to which has been added in dotted lines the valve opening and pressures for regulator as described in Figure 1, for comparison with the regulator considered by Prof. Trinks. It will be seen that with the former type of regulator the valve opening follows directly the variations in pressure and at no time is it over-travelling—i.e., the valve continuing to open after the pressure has begun to fall, which is the cause of the oscillations analyzed by Prof. Trinks. It will be noted in Figure 4 that the valve opening corresponds to changes in pressure and is in phase therewith. It is this characteristic on the diagram which makes for stability, since it does not indicate over-travel. On the diagram of Prof. Trinks, the regulator which he describes shows a valve motion which occurs at a time lag behind the pressure change and therefore characterizes the condition for oscillation, which is that the moving parts move at an appreciable time interval behind the changes in controlling pressure, a condition held in common with the swinging pendulum. This arrangement accomplishes in a direct manner what Prof. Trinks has in mind in suggesting the time switch, which would reduce the over-travelling of the valve shown be-

tween points "8" and "6." It does not occur to us, however, that this is a complete solution of the problem, nor does Prof. Trinks appear to so regard it.

The company with which the writer is connected has developed a regulator which fulfills the conditions outlined above and has a high degree of sensitiveness to minute pressures, and which also largely eliminates the retarding effect of mass inertia. By means of this type of regulator the control valve without appreciable time lag takes positions corresponding to the controlled pressure, the apparatus having all the characteristics of a stable-acting regulator as outlined above.

We take exception to a statement of Prof. Trinks contained in the lower righthand corner of page 462 of the October issue of the Blast Furnace and Steel Plant in which he says "A very quick operation of the regulating valve upsets the exhauster governors in case of sudden variation in gas supply." It occurs to us that the requirements of the plant demand of the exhausters that they handle the gas from the ovens as rapidly as generated. There is some storage between the governor and the exhausters, due to the rather high suction of this point, which serves to equalize the flow to the exhausters. It is obviously impossible for the governor to regulate in case the exhausters fail to handle the volumes which may come and we do not see any advantage in retarding the action of the regulator in order to favor the exhausters. It occurs to us that this statement of Prof. Trinks involves that the regulator choke the ovens by piling up an opposing pressure in the event of a sudden rush of gas in order to favor the exhauster regulators. Such a method of operation means the partial abandonment of pressure regulation on the ovens in the event of an abnormal rush of gas.

Note.—The description of the regulator discussed in Prof. Trinks' original article is added: A counterweighted, thin walled float dips in oil. Atmospheric pressure acts downward, coke-oven-main pressure and counterweight act upward. If one of the forces exceeds the other, the float moves and closes an electric circuit which, in turn, starts an electric motor and thereby operates a valve in the gas main, varying the rate of flow from the oven to the exhauster. In practise more machinery is used than is shown in the diagram. Two sets of spur gears are interposed between motor and worm and a variable lever arm connection is used between the worm gear and the butterfly valve. The whole apparatus is enclosed in a housing which is intended to be air-tight, with the exception of a few small holes at the bottom. This is very important. Wind regularly causes pressures up to 100 m.m. of water, so that wind pressure getting into the governor box would play havoc with regulation which aims to regulate within 2 m.m. pressure. As a matter of fact, regulation is much worse on windy days than it is on calm days.

Operation of Grab Bucket Coal Hoists

Alternating Current Motors With Dynamic Braking and Regenerative Braking—A. C. and D. C. Installations Compared With Regard to Most Important Features.

By JAMES FARRINGTON and R. H. McLAIN.

Since alternating current is the most economical form in which to generate and transmit electric power, it is incumbent on electrical engineers to study its application to machinery to see if alternating current is not "just as good as" direct current. Of course, there are numerous cases where alternating current motors are better, from every standpoint, than direct current motors, but in order to establish the desirability for using an alternating current motor, it is never necessary to show that the alternating current motor produces better results. It is only necessary to show that it is just as good as the d-c. motor, and in some cases, even if the a-c. motor characteristics are a "shade worse," the a-c is preferable unless the "shade worse" refers to the quality and quantity of the output of the machinery or the plant. This paper will discuss some of the methods of hoisting coal by alternating current.

In order to portray more clearly the status of alternating current motors for this coal hoisting work, a brief comparison will be made between an alternating current installation and a direct current installation. This comparison will be made only in regard to the more important features. As regards transmission systems, the alternating current is, of course, easier to transmit at high voltages than is the direct current at its usual voltages which are low, but when the alternating current has to be transmitted at low voltages and where long collector rails have to be installed, alternating current is really at a disadvantage because three wires are required, whereas with direct current only two wires are required and in some cases one of these wires may be grounded. Peculiar local conditions have so much to do with the cost and feasibility of the transmission system that it will not be attempted to go into this phase of the situation more fully in this paper. Frequently the local conditions are such that the difficulty of using a proper transmission system with alternating current really decides the case in favor of direct current.

The next point of comparison is in regard to hoisting the load. For this purpose an alternating current motor and a direct current motor are practically on a par. Suitable speeds for gearing or direct connecting can be obtained with either motor; and power economies, maximum torque and other features are practically the same. However, it is necessary, where an alternating current motor is used, to go to greater trouble and

expense to maintain a uniform voltage than it is where a series wound, direct current motor is used because a widely fluctuating a-c. voltage might result in a good motor failing to exert proper starting torque; whereas with direct current series motors, line voltage has practically nothing to do with the starting torque.

The direct current motor has, by far, the advantage over the alternating current motor for accelerating heavy loads to high speeds. For instance, on a man-trolley or other propelling motion where the maximum speed to be attained on a horizontal track is something like 1000 feet per minute, the alternating current motor would have to weigh approximately twice as much as the direct current motor and be twice as large in every respect in order to accomplish the same amount of work. This peculiar advantage in the direct current motor has been explained many times by making an analysis of the speed torque curves of the motor. No detailed comparison will be made in this paper. This advantage of the d-c. motor over the a-c. motor does not amount to much on slow speeds like 300 or 400 feet a minute for trolleying purposes, and hardly amount to anything for any of the particular hoisting speeds and hoisting conditions which are used in this class of work.

The big problem, so far, on most coal towers has been the problem of lowering the bucket. This problem has been solved and practically standardized where direct current is used by making use of dynamic braking. The direct current motors and direct current control lend themselves admirably to dynamic braking and this kind of braking can be used to the fullest extent without adding very much to the size of the motor or to the complexity and cost of the control. Up to the present time this problem has not been so thoroughly solved with alternating current motors as to result in any settled practice. We will undertake to point out in the following paragraphs some of the fundamental problems involved in lowering buckets and some of the solutions which have been made.

In order to lower a bucket properly into a boat without damage to itself or the boat, it is necessary to maintain a uniform speed of some certain amount just as the bucket is about to strike the bottom of the boat. The exact value of this speed will depend on the size of the bucket, the amount of coal in the boat and kind of boat used. For large buckets like the 5 and 10 ton buckets used on the Great Lakes in connection with large steel boats, it is desirable to have a bucket speed of something like 40 to 60 feet per minute. Two and

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three ton buckets used on these same boats might very well be lowered at a speed of about 150 to 200 feet a minute. Two and three ton buckets, when used on wooden barges, should be lowered at a speed about 125 feet a minute. Of course the slower the speed, the less damage will be done to the boat and the bucket. On the other hand, it is not necessary to go below speeds named above and furthermore a lot of time can be wasted in running at slow speed if too much stress is laid on running at slow speeds. In fact, when digging in deep coal where there is no danger of striking the boat, it is desirable for the bucket to enter the coal at

vision whatsoever for reducing the speed of the motor as the bucket strikes the boat. It is necessary to provide some kind of a brake for stopping the motor and also for holding the bucket suspended after the motor is stopped. For these purposes, the ordinary commercial solenoid brake is well adapted. This is called regenerative control and makes a very simple outfit indeed.

When the motor is geared for higher hoisting speeds than 125 feet per minute, the same method of control can be used as outlined in the paragraph above, but it is necessary to design the solenoid brake carefully so that it will meet the heating requirements of the duty cycle



Typical grab bucket coal hoist, at the La Belle Iron works.

a high speed, something like 500 or 600 feet a minute, so that the blades of the bucket can penetrate well into the coal and thereby increase the digging capacity of the bucket.

In order for an alternating current motor to be used successfully with this kind of work it is necessary to obtain some kind of a method of controlling its speed when lowering the bucket so as to accomplish the results described in the above paragraph. If, for example, the motor is geared for a hoisting speed of 125 feet per minute and a 3 ton bucket is used, all that is necessary to do is to put on plain reversible control with no pro-

and it will be necessary to provide it with easy means of adjustment so that it does not stop the load too quickly or too slowly. With such an outfit an operator can, by exerting care and skill, shut off the motor from the line at a proper distance above the point where it is to strike the coal or boat and bring the bucket down to a practical stop by means of the solenoid brake before it strikes the boat. This method of control is not very satisfactory if there is much variation in the load—that is, if at some times a loaded bucket has to be lowered and stopped and at other times an empty bucket has to be lowered and stopped. It puts a great strain on the operator and

is not practical if the speed is very much over 125 feet per minute and if more than one trip per minute has to be made. However, such method of control is practical up to hoisting speeds of around 300 feet per minute, if two solenoid brakes are used with controlled points for each solenoid brake. Such a combination gives the operator a more flexible control of his speed and enables him to handle the bucket quite readily. Hoisting machines having speeds as high as 1200 feet per minute have been operated by lowering the bucket at full speed regenerative control and then stopping it by means of one solenoid brake in combination with one foot-operated brake used for assisting the solenoid brake. The foot-operated brake gives the necessary flexibility to the outfit to make it easy and practical for the operator to handle the bucket at proper speeds as it approaches the boat. Hoisting machines have been worked out where the bucket was lowered by means of regenerative braking at speeds around 700 or 800 feet per minute and stopped by shutting off power and applying air brakes. Air brakes give the necessary flexibility of speed control because graduated braking can be obtained.

All of the schemes outlined in the above paragraph are thoroughly all right and practical so far as getting control of the bucket speed is concerned, but when buckets greater than two tons capacity are used at rope speeds above 500 or 600 feet per minute, making trips more rapidly than two trips per minute, it becomes very hard to design and build proper friction brakes which can withstand the wear and tear and get rid of the heat generated in a rapid duty cycle. It is for conditions beyond the above limitations that dynamic braking can be used to solve the problem. Dynamic braking can be used in combination with regenerative braking—that is, the bucket can be lowered practically the whole distance by regenerative braking and then stopped from full synchronous speed of the motor down to something like 120 feet per minute on the bucket by means of dynamic braking. Some kind of a friction brake is required to hold the load and stop it from 120 feet per minute, but this friction brake is relieved of all wear and heating which would be encountered if dynamic braking were not used. It is also feasible to use dynamic braking, not only for stopping the load but for lowering the load as well. The choice between the use of regenerative braking in combination with dynamic braking, or dynamic braking alone, should be based on various considerations such as the cost of power, the adaptability of the particular motor sizes to dynamic braking and the complications. If a large amount of power can be saved by using regenerative braking and if regenerative braking can be left on for a long period of time in lowering the choice should generally be made in favor of a combination of regenerative and dynamic braking; but if power is not very expensive and if regenerative braking could not be left on for more than two or three seconds while in the act of lowering, there

is hardly any use of complicating the situation by the use of regenerative braking.

Two different schemes of dynamic braking have been proposed and used for this kind of service. These will be referred to as scheme A and scheme B. One scheme, A, makes use of the following electrical apparatus:

1—A-C hoist motor.

1—Motor generator set for changing alternating current at incoming line voltage into direct current at low voltage, suitable for exciting the a-c. motor field.

1—Exciter for the above motor generator set which generates either 125 or 250 volts direct current. This exciter is used for exciting the fields of the generator and is sometimes used for supplying power for operating the control apparatus.

1—Master controller.

1—Contactor panel.

1—Resistor.

An alternating current coal hoist making use of the above method of control was described and discussed at the April 15th and 16th meeting of the A. I. E. E. at Pittsburgh in 1915. The paper was presented by R. E. Brown, and is found on page 983 of the "Transactions of the A. I. E. E., part No. 1, vol. 34.

Scheme B makes use of the following material:

1—A-C hoist motor.

1—D-C series wound motor of about 10 or 15 per cent of the rating of the hoist motor directly coupled or geared to this hoist motor.

1—Tungar rectifier for separately exciting the above d-c. series motor (optional).

1—Master controller.

1—Contactor panel.

1—Set of resistors.

Since the first scheme has been thoroughly described in Mr. Brown's paper, no further detailed description will be made of it in this paper, but a detailed description of the second scheme will be made.

The advantages of both of these schemes over friction braking are the following:

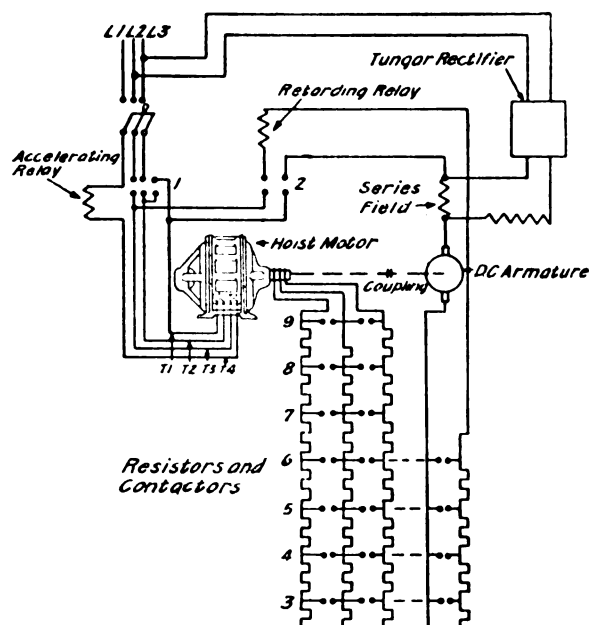
1.—There is less wear and tear on the friction brakes and consequently less maintenance.

2.—The friction brakes do not have to be built so large and consequently less power is wasted in starting and stopping the revolving elements on the brakes themselves.

3.—While it is practical to use friction brakes within certain limits of weights and speeds as have been pointed out above, yet a great deal of care and skill is required on the part of the operator to prevent landing a bucket too hard on the boat. With dynamic braking, each step of the controller gives a definite uniform speed and consequently an operator can land his bucket properly without having to exert such great care and skill, and it is only reasonable that he would be able to do more work with less accidents when using dynamic braking.

We would like to point out a few comparisons of the fundamental differences between the first and second scheme of dynamic braking mentioned above:

1.—In scheme A, the a-c. motor has to exert all of the torque for lowering the bucket. In scheme B the direct current motor would normally take about 20 to 25 per cent of the torque required for lowering the load, but could, with slightly additional expense, be made to take a greater value should this be necessary. This is quite an advantage in favor of scheme B, because under ordinary conditions an alternating current motor, which is not worked close to its margin for hoisting torque may be very close to its margin for lowering torque, especially if a loaded bucket has to be lowered under some conditions. Any assistance which it can get from the direct current motor, is valuable not only in keeping the size of the a-c. motor down due to torque limits but also due to heating limits. The amount of d-c.



Elementary diagram of connections of induction motor and D. C. motor connected for dynamic braking—To hoist contactors 1, 3, 4, 5, 6, 7, 8, 9 are closed in sequence—To lower at high speed contactor 2 is closed—To lower at low speed contactors 2, 3, 4, 5, 6 are closed in sequence.

excitation which has to be sent through a stator of an alternating current motor to obtain the necessary torque for dynamic braking may even exceed the alternating current which is required for hoisting the load.

2.—On account of the assistance given from the direct current motor, scheme B can be designed to give a lower value of creeping speed in the lowering direction than can scheme A.

3.—In scheme A, the amount of direct current excitation must be arranged to take care of the maximum load which is to be lowered. For example, it might take 1000 amperes direct current excitation to lower a loaded bucket and 700 amperes excitation to lower an empty bucket. Arrangements would have to be made so as to use 1000 amperes excitation at all times so as not to drop a loaded bucket if it happened to be put on. In scheme B the amount of direct current excitation automatically regulates itself just as it does in a series

wound d-c. motor; that is, if a loaded bucket is being lowered, the excitation in this case would be, say 900 amperes (it would be less than in the first case because of the assistance given by the first current motor), and with an empty bucket 600 amperes. The heating on the a-c. motor due to this separate excitation would, therefore, vary with the load and would not be constant at the maximum load.

4.—With scheme A, when the operator brings the master controller to the lowest speed point, lowering, he leaves full excitation on the motor. If he should bring the a-c. motor to rest by means of the friction brakes, he would, in a large number of trips, leave direct current excitation on the a-c. motor when it is at a standstill for a considerable period of time and this incorrect operation would accumulate in the form of wasted power and also of additional heating in the a-c. motor. With scheme B, the excitation dies out immediately that the motor comes to rest. This scheme involves no such waste of power whatsoever and relieves the a-c. motor of any useless heating.

5.—Power consumption due to auxiliary equipment for dynamic braking will be greater in scheme A than in scheme B. In scheme A it is necessary to use a motor generator set driven by a motor rated at about 2 per cent of the main hoist rating. The no-load losses of this set are drawn from the line continuously and even if the power consumption, incidental to supplying excitation, were the same for the two schemes when operating at full capacity of the plant, the second scheme B would be at an advantage under practical working conditions because these plants spend so much of the time idle and during the idle period the no-load losses with scheme B are less than one-half of what they would be with scheme A. Most of the power for dynamic braking in scheme B is spent on accelerating the armature of the small d-c. motor. WR^2 of this armature is about 5 per cent of the WR^2 of the hoist motor armature, so that this amounts to practically nothing. Furthermore, it is likely, in a large number of cases, that the main hoist motor, under scheme A would have to be so much larger than under scheme B on account of additional heating and torque requirements which have been pointed out above, that a larger size hoist motor would have to be used in scheme A than in scheme B. In such a case, the flywheel effect of the larger a-c. motor would be greater than the combined flywheel effect of the smaller a-c. motor and the direct coupled d-c. motor.

Below are worked out in detail the power requirements for the hoisting plant using scheme B which will be described later:—46 kw. seconds are required for each round trip to be spent for dynamic braking and 400 watts will be the no load losses when the plant is idle. If scheme A were used, $45\frac{1}{2}$ kw. seconds would be required for excitation for every round trip, and no-load losses would be 750 watts. This last figure is made on the assumption that the operator does not leave d-c.

excitation on the alternating current motor except when it is absolutely required and motor is in motion. If the operator should operate in any except a theoretically perfect manner, the kw. losses per trip would be increased largely.

6.—Scheme B is better from a continuity standpoint than scheme A because it relies on only one direct current machine in order to get proper excitation for lowering, whereas scheme A relies on two direct current machines and one alternating current machine. It should be noted that the Tungar rectifier mentioned above in list of apparatus is optional. Scheme B is perfectly operative without the use of this Tungar rectifier, that is, if the Tungar rectifier should fail, the tower could go right along using dynamic braking. The purpose of the Tungar rectifier is to render the dynamic braking speed more staple by making the d-c. motor build up quicker and more positive than it would do without the Tungar rectifier. It also has the advantage of making the minimum creeping speed somewhat lower than would otherwise be obtained. Generally speaking scheme B is more self-reliant and independent than scheme A.

7.—There undoubtedly are certain hoisting machines whose dimensions would not permit readily of the use of scheme B, since it might make an awkward mechanical layout and in such cases scheme A would be the more

advantageous scheme to use. Certainly this mechanical limitation will not occur on towers where the hoisting machinery is stationary with respect to the bucket. It might occur on crowded man-trolleys on similar peculiar locations.

8.—The speed torque curves in scheme B are more flat than in scheme A. This means that if a given point on the controller is laid out properly for lowering an empty bucket at, say full speed of the motor, this same point on the controller, without any assistance from automatic relays or other complicated devices, would with scheme A, lower a loaded bucket at about 50 per cent above the normal speed; whereas with scheme B, it would lower a loaded bucket at only about 15 to 20 per cent above normal speed. This is due to the fact that as load comes on, the series motor used in scheme B increases its speed, the direct current through its fields increase and this gives an increased torque per ampere which tends to prevent an increase in load from making a corresponding increase in speed. In other words, characteristics of scheme B in regard to change in speed with change in torque are very much the same as are the characteristics of a series wound, self-excited, direct current motor when used for dynamic braking, whereas the characteristics with scheme A correspond to the separately excited shunt wound direct current motor used for dynamic braking.

Rolling Mill Power Requirements

Derivation of Formula Giving the Work Necessary to Roll Steel.
Data Showing Relation of Pure Work of Rolling Required and
Total Work Furnished.

By F. DENK.

Prof. Lang (see October issue, p. 451) states in his article, that, at the present time, there is no formula at hand, which permits the calculation of the power requirements for rolling steel under all rolling conditions, and that it hardly will be probable, that such a general formula ever will be found. This is the standpoint taken since tests and investigations for the determination of mill power have been made (see August, 1917, issue of this magazine, pages 367 and 368). On the other hand, it is possible to get results for simple conditions, for instance for blooming and similar mills.

Following Prof. Herrmann's derivation (Stahl und Eisen, October 19, 1911, p. 1706), Prof. Lang arrives at a formula, which gives the work necessary to roll steel in the following form:

$$L = F \times K \times V_D \left(1 + \frac{1 - \cos \alpha}{2}\right) + 2F \times K \times V_D \left(1 + \frac{1 - \cos \alpha}{2 \sin \alpha}\right) m \quad (1)$$

where

L = work done,
F = reduction in area,

K = factor depending on different rolling conditions,

V_D = velocity of roll surface,

α = angle of rolling,

V_a = velocity of roll neck surface, and

m = coefficient of friction.

If both sides of equation (1) are multiplied by the time "t" in seconds, and if it is kept in mind, that the velocity of the roll neck surface is proportional to the velocity of the surface of the rolls proper, ($\alpha \times V_D$), the equation will be,

$$L \times t = F \times K \times V_D \times t \left(1 + \frac{1 - \cos \alpha}{2}\right) + 2m \alpha \left(1 + \frac{1 - \cos \alpha}{2 \sin \alpha}\right) \quad (2)$$

The time can be expressed by "length of the ingot divided by velocity," or $t = L/V_D$. This inserted in the right side of equation (2) gives the product $F \times 1$, which represents the "displaced volume." Dividing by this product, we obtain on the left side the value

$$\frac{L \times t}{F \times 1}$$

which represents the power required per unit of mass

and may, for our purposes, be taken as HP-sec's/cu. in. Equation (2) now becomes

$$\frac{\text{HP-sec's}}{\text{cu. in.}} = K \left[\left(1 + \frac{1 - \cos \alpha}{2} \right) + 2 m a \left(1 + \frac{1 - \cos \alpha}{2 \sin \alpha} \right) \right] \quad (3)$$

The factor "K" depends on the temperature, the roll diameter, the height of the ingot and the velocity. The terms within the brackets express, in different relations to each other, the roll diameter and the height of the ingot before and after the pass. This can easily be seen from Fig. 1, which gives the relation between the angle of rolling α , the roll-radius "R" and the draft $d = H - h$, viz:

$$\sin \frac{\alpha}{2} = \frac{1}{2} \sqrt{\frac{d}{R}} \quad \text{and} \quad \sin \alpha = \frac{\sqrt{d(4R-d)}}{2R}$$

$$\cos \frac{\alpha}{2} = \frac{1}{2} \sqrt{\frac{4R-d}{R}} \quad \text{and} \quad \cos \alpha = \frac{2R-d}{2R}$$

The influence of the temperature can be separated entirely from the rest of the conditions and may be expressed by $f(T)$. The other factors, however, can

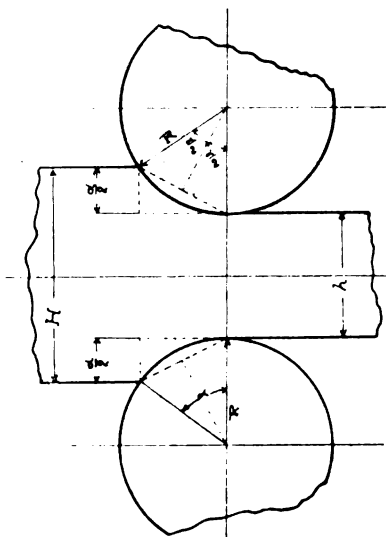


Fig. 1.

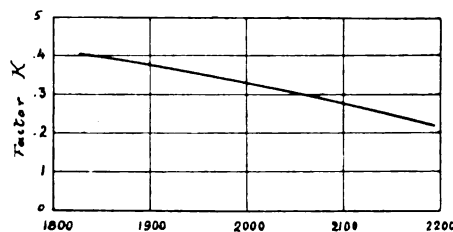


Fig. 2.

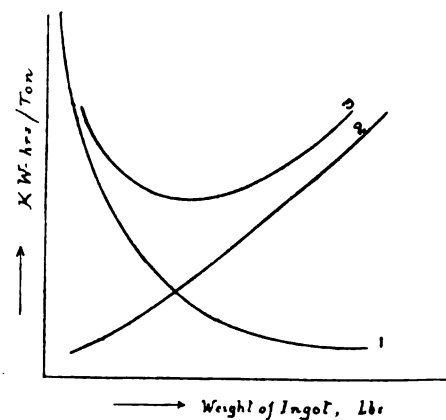


Fig. 3.

not be separated as easily, but they may be combined into another function, say $f_1(D, H, h, V_D)$. Thus equation (1) changes into

$$\frac{\text{HP-sec's}}{\text{cu. in.}} = f(T), f_1(D, H, h, V_D). \quad (3)$$

The writer's formula equation (3) compares with Prof. Lang

$$A = C \sqrt{\frac{d \times R \times W}{S}} \quad (4)$$

Using notations similar to those in equation (3), we have

$$\frac{\text{HP-sec's}}{\text{cu. in.}} = f(T) \sqrt{\frac{D, H - h, W}{S}} \quad (4a)$$

having replaced

$$\begin{aligned} A &\text{ by } \frac{\text{HP-sec's}}{\text{cu. in.}}, \\ C &\text{ by } f(T), \\ d &\text{ by } H - h, \quad \text{and} \\ R &\text{ by } D. \end{aligned}$$

The speed of the rolls "S" can be expressed by the velocity of the roll surface. The weight of the ingot contains the dimensions, including the height. But, since the length and the width of the bloom can be expressed in terms of the height, the weight of the ingot is practically only a function of the height, assuming, of course, that the ingots in question have a similar shape. This, however, is the case on all blooming mills, three-high as well as two-high. For this reason, equation (4) or (4a) can be written in the same form as equation (3), i. e.:

$$\frac{\text{HP-sec's}}{\text{cu. in.}} = f(T), f_1(D, H, h, V_D). \quad (5)$$

Comparing the two equations and the factors influencing the power required to roll steel, Prof. Lang maintains that both equations agree almost exactly in regard to the influence of the temperature. This can be seen by comparing the curve Fig. 2 with the lowest curve in Fig. 4 (see October issue, p. 450).

Fig. 2 is the reverse of the original curve in "Stahl und Eisen," which had to be redrawn, in order to make the identity more apparent. Between about 1,920 and 2,150 deg. F. the two curves are identically the same, which proves, that the influence of the temperature is taken care of in the proper way. A little adjusting may be all that is necessary to make the two temperature curves check exactly.

The influence of the roll diameter upon the power requirements is, in both equations, taken care of in the same manner, in so far as they both show an increase in power for an increase in the roll diameter. A direct comparison, however, is difficult, on account of the different ways, in which this influence is considered in the two formulae, but it can be said, that in general both equations consider the influence of the roll diameter upon the mill power in such a way that it corresponds well with actual rolling conditions.

As far as the two items mentioned above are con-

cerned, viz. the temperature of the ingot and the roll diameter (or roll radius), the two equations agree well in the way they take care of them. For the rest of the important factors, i. e., draft, weight of the ingot and speed of the rolls, the two formulae differ to a certain extent.

Referring to the weight of the ingot, Prof. Lang says, that he cannot see which influence this factor could have on the power requirements. According to the statements made above, he rather believes, that this influence, if it exists at all, is rather to be attributed to the height of the ingot, which in turn has some connection with the draft. Nevertheless, if the weight of the ingot be replaced by the product: Volume $\times$ specific weight, and if the volume is expressed by "h," the factor h^3 appears or, since "h" is under the root sign, we have $h^{3/2}$. For blooms or ingots of like shape, the two equations then have a very similar form.

The main reason why no influence of the weight of the ingot upon the rolling power could be discov-

eleration losses must be added separately. Keeping these facts in mind, it can easily be seen, that the two equations must differ entirely in regard to the influence of that rolling speed upon the power requirements. Even for the pure work of rolling the power can go up towards the end of the rolling process, if the actual rolling temperatures are considered, or if the draft becomes high in the last passes, notwithstanding the fact that the rolling speed may be high. The weight of the ingot can be disregarded here, since it is practically constant during rolling. Figuring on about 2 per cent scale losses, a three-ton ingot will weigh 2.94 tons after rolling, which difference can be neglected, the more so since the largest amount of the scale falls off during the first passes.

To prove the statement in regard to the increase in power with increasing speed, if the actual rolling temperature is concerned, we may refer to Fig. 3 in last month's article (page 450 of the October issue), where the difference in the location of the actual points and the theoretical points may plainly be seen. The

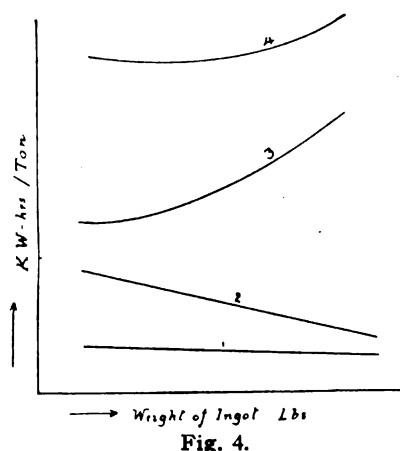


Fig. 4.

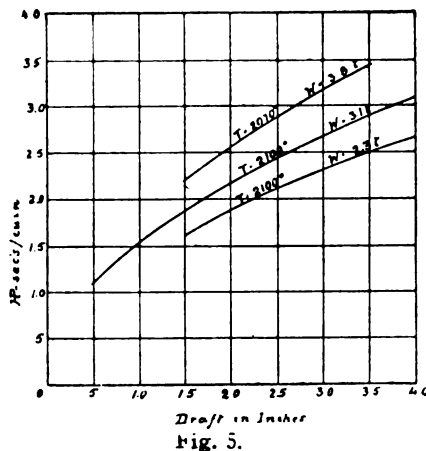


Fig. 5.

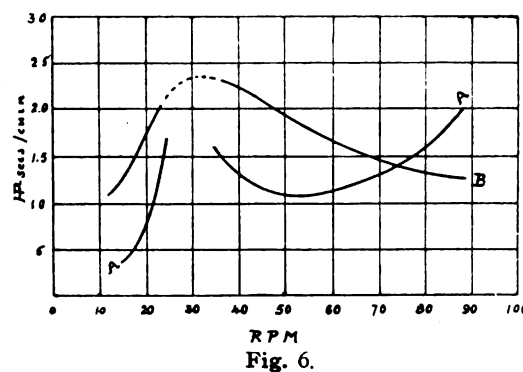


Fig. 6.

ered by Prof. Lang, may be due to the fact that his investigations were confined to small billets only, weighing not more than about $1\frac{3}{4}$ tons. The writer, on the other hand, investigated data from blooms and ingots, weighing between two and four tons and in some cases even more than that. The results of the last-named investigations will be shown later in connection with results found by Dr. Puppe.

No agreement seems to prevail between the two formulae in regard to the speed. In Prof. Lang's equation, the power required increases with the speed, while the reverse condition holds good for the writer's formula, at least for speeds above about 35 r.p.m. This seemingly irreconcilable condition can be solved, when it is considered that the first named equation takes into account pure work of rolling and friction load under any rolling conditions, while the last-named formula takes care only of the pure work of rolling under certain specified conditions, i. e., an average rolling temperature, with all the other factors referred to unity: Friction losses and, for reversing mills, ac-

celeration losses must be added separately. Keeping these facts in mind, it can easily be seen, that the two equations must differ entirely in regard to the influence of that rolling speed upon the power requirements. Even for the pure work of rolling the power can go up towards the end of the rolling process, if the actual rolling temperatures are considered, or if the draft becomes high in the last passes, notwithstanding the fact that the rolling speed may be high. The weight of the ingot can be disregarded here, since it is practically constant during rolling. Figuring on about 2 per cent scale losses, a three-ton ingot will weigh 2.94 tons after rolling, which difference can be neglected, the more so since the largest amount of the scale falls off during the first passes.

To prove the statement in regard to the increase in power with increasing speed, if the actual rolling temperature is concerned, we may refer to Fig. 3 in last month's article (page 450 of the October issue), where the difference in the location of the actual points and the theoretical points may plainly be seen. The difference is caused by the high final rolling temperature and not by the high rolling speed, as will be demonstrated below.

In the foregoing it was shown that Prof. Lang's equation and the writer's equation have the same general shape; that they, furthermore, agree in regard to the manner in which the influence of the temperature of the ingot and the roll radius (or diameter) upon the power is taken care of, but that they do not agree in regard to the way in which weight of the ingot and rolling speed are considered. The reasons for these discrepancies have also been explained. In the following we will show, in how far the writer's statements can be verified by his own data and by those of other investigators.

In 1915 (Stahl und Eisen No. 19 and 20) Prof. Puppe has published results of investigations, which show plainly, that the pure work of rolling increases with the weight of the ingot, although the total power, i. e., the power for the pure work of rolling plus the power necessary to overcome friction and—where

needed—acceleration losses, may drop. In Fig.'s 3 and 4 curves are shown which illustrate these conditions. In Fig. 3, curve No. 1 represents the friction load, curve No. 2 the pure work of rolling and curve No. 3 the total rolling work, for a three-high mill, while Fig. 4 illustrates similar curves for a reversing mill, No. 1 representing frictional losses, No. 2 acceleration losses, No. 3 pure work of rolling and No. 4 the total mill work. The two curves, illustrating the pure work of rolling are seen to increase with the increasing weight of the ingot. It would be going too far, to enter farther into details; suffice it to say, that Dr. Puppe proves beyond doubt, that these conditions prevail.

Fig. 5 shows curves plotted from data obtained by the writer. The three curves represent test data from three different ingots, weighing 2.3 T., 3.1 T. and 8.8 T. respectively. The influence of this difference in weight upon the power requirements is clearly visible, and it proves again that the power increases with increasing weight. It may be stated here, that the average rolling temperatures are 2,100, 2,100 and 2,070 deg. F. respectively, which latter value also influences the location of the highest curve (3.8 T.).

In a similar manner, Dr. Puppe has published in the same article curves, which show, that increasing the rolling will decrease the pure work of rolling, although, due to other conditions, the total work may increase. A very good illustration of this condition can be seen in the curves of Fig. 6, which represent test data taken from a 35 in. reversing mill and investigated by the writer. The left branch of curve "A" shows increasing power requirements with increasing speed up to about 25 r.p.m. This verifies the statement made on several occasions by the writer. Between 25 and 35 r.p.m. a break in the curve occurs, but from about 35 r.p.m. on the power drops first and then rises considerably. This rise in power with increasing speed in the right branch of curve "A" is due to the drop in rolling temperature toward the end of the rolling process; referring the data to the aver-

age rolling temperature gives curve "B," which shows again the increase in power with increasing speed at the right side of the curve.

The same conditions have been found through investigating test data from other mills, for instance, from a 34 in. electrically driven reversing mill, where the rolling also was started with a very low speed, so that the curve has two branches: increasing in power up to about 30 r.p.m., then a break, and then, from about 40 r. p. m., decreasing in power with increasing speed, but only, when the average rolling temperature is considered, and when the other factors are taken as unity. For many reversing mills, the left branch can be omitted, since the average rolling speed at the beginning does not drop below 35 or 40 r.p.m., while for three-high mills, to the writer's knowledge, this speed will always be higher. For this reason, no attempt has been made to complete equation (4) in such a way, that it may take care of these conditions. This, however, will be done, as soon as more facts, covering these conditions are at hand.

In order to use equation (4) in the right way, it must not be forgotten, that the pure work of rolling is only a certain percentage of the total work to be furnished. This percentage varies greatly with the type of engines and mills used. From a large number of data collected from tests made on different types of mills, the following percentages have been found:

The pure work of rolling amounts to

55 per cent on reversing mills driven by engines running non-condensing.

65 per cent on reversing mills driven by engines running non-condensing.

75 per cent on reversing mills geared, driven by engines running non-condensing.

80 per cent on reversing mills geared, driven by engines running non-condensing.

82 to 83 per cent three-high mills, driven by engines running non-condensing.

If these conditions are observed, equation (4) should give practical results.

Electric Power Economy Factors

Rapid Increase in the Scope of Application of Electric Power
Makes Its Generation an Important Question from the
Standpoint of Economy.

By BRENT WILEY,

Commercial Engineer, Westinghouse Electric & Manufacturing Company.

The importance as well as the magnitude of the steel industry is growing rapidly and the many problems that arise with the efforts to improve mill capacity and quality of the steel with better economy and safer work-

ing conditions warrant an ever increasing consideration.

While it is true that even a decided improvement in the economy of the power required to produce a ton of steel in the finished state would vary its total cost only a fraction of a per cent, as considered from past practice —this item is fast becoming a more serious one. Con-

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ditions are changing to materially increase the power cost. The supply of natural gas is giving out rapidly in many localities which formerly found it a cheap fuel, and the price for coal is increasing very fast. The question of transportation together with the greater demand for coal have added serious problems to the plant's management list. Thus, to-day added effort is being made to utilize every available heat unit to the best advantage and every steel plant will do well to review their conditions thoroughly to see that their practice is giving them the best results in this respect.

The many phases of economical power generation as developed during the past ten years have covered many points to a fairly well established conclusion, and it might prove of value to review some of these factors to see to what further extent they could be modified and adopted to an advantage in various plants.

It is important to emphasize the value of planning for future developments, for in order to meet the rapidly increasing demands of the steel industry successfully,

trary, the power plants, in general, are composed of a number of comparatively small and inefficient units.

One of the first factors which developed marked improvements in power plant engineering, as relating to the larger mills, was the rapid growth of steel capacity. With the increase in size of plants and amount of power required, alternating-current power was adopted approximately twenty years ago. The higher voltage greatly simplified the transmission problems and the larger capacity and high speed type of generating units gave increased economy. Figure 1 gives the steel ingot output since 1901 as shown by curve (a), and curve (b) gives the approximate steel making capacity of the mills of this country. According to the latter, the steel capacity has doubled within the last twelve years, being at present 48,000,000 tons per year (as will be completed by January 1, 1918). A curve similar to (b) could be plotted to show the increase in auxiliary motor load requirements, using the following general basic data: Total horsepower of auxiliary motors installed per

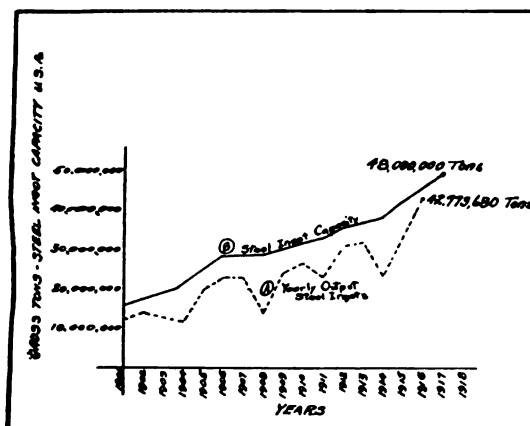


Fig. 1.—Steel ingot output since 1901.

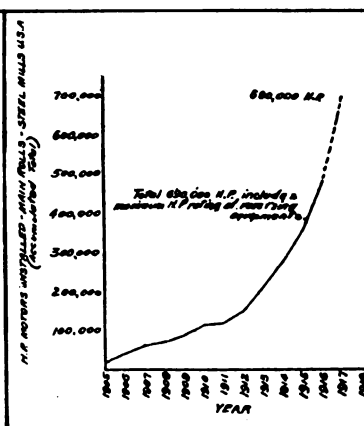


Fig. 2.—Shows the yearly installation of main roll drives since 1905.

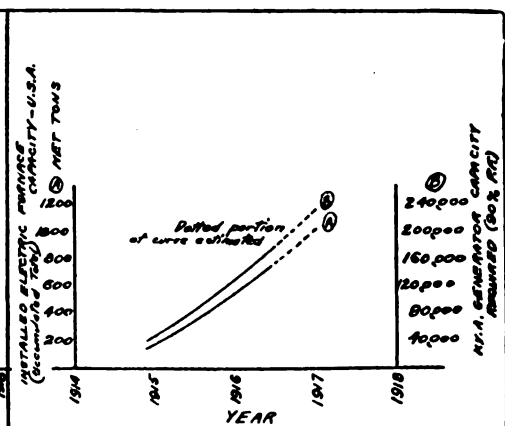


Fig. 3.—Growth of electric furnace capacity since 1914.

the electrical power engineer must follow a very broad policy.

During the earlier periods the plant area was rather limited and the distribution of 250-volt direct current power to the auxiliary machines was easily provided for (as a rule within a radius of 2000 feet.) The requirements of the station were small and improvements to the plant called for additional power in limited amounts. The power station usually consisted of two or more units ranging from 200-kw. to 750-kw. capacity. These were driven by slow speed engines in many cases — 125 pounds steam pressure—non-condensing, and the speeds ranged from 125 to 200 r.p.m. A steam consumption of 35 pounds per kw-hr. was considered fair practice. No comprehensive design of power plant was considered necessary, and as a result the station just grew. Even to-day there are but few plants, where the majority of power is used for auxiliary machines which are composed of modern generating units, installed in accordance with broad engineering principles. On the con-

year to steel capacity, .025 horsepower. (This includes power for blast furnace department.) Generating apparatus installed per horsepower of auxiliary motors, .15 kw. (Spare unit not included).

With the advent of motor drive for the main rolls which became a real factor approximately 10 years ago, the electric power plant began to receive serious consideration by the management of those plants directly interested in this application. For every horsepower of main roll motor drive it requires approximately .5 kw. of generating capacity, which is about three times that necessary for a horsepower of auxiliary motors. Figure 2 shows the yearly installation of main roll drives from 1905 to January 1, 1918 installed. A very close estimate can be made for the total of 1917 as the question of delivery practically limits the installed units to the total included in sales to July 1, 1917. During the last five years the total horsepower installed has increased 400 per cent.

A third factor which is rapidly increasing the demand

for electric power in the steel industry is the electric furnace. There were 36 furnaces of approximately 191 net tons capacity installed in the United States January 1, 1916, requiring approximately 40,000 kva. (90 per cent P.F.) generating capacity. Curve (a) of Figure 3 shows the growth of furnace capacity since this date and curve (b) gives the generating capacity required. Estimates have been made for the last half of this year, based on sales made to July 1, 1917.

Summarizing the power requirements of these three factors, regarding generating capacity required, we have the following data—in terms of average rate of yearly increase :

December 31, 1905-1909		Kw.
	Main motors	10,000
	Electric furnaces	
	Total	15,000
1909-1913		Kw.
	Auxiliary motors	10,000
	Main motors	16,000
	Electric furnaces	4,000
	Total	30,000
1913-1915		Kw.
	Auxiliary motors.....	13,000
	Main motors	25,000
	Electric furnaces	12,000
	Total	50,000
1915-1917		Kw.
	Auxiliary motors	20,000
	Main motors	75,000
	Electric furnaces	75,000
	Total	170,000.

A composite curve as given in Figure 4 shows the growing demand for electric power and it is of particular interest to note the unusual increase as given for the past two years. This rapid increase in the scope of application of electric power and amount required makes the generation of power a more and more important question, particularly from the standpoint of economy. It would be well to analyze this point as applying to various steel plant conditions and give a general outline of the several phases of economy as adopted in existing plants.

The broad problem of economical power generation for practically every steel plant work to-day includes the study of one or more of the following points: Proper utilization of the heat units of coke oven gas from the coke plant—blast furnace gas in pig iron production—and waste gases from open hearth and re-heating furnaces.

Coke oven gas is used as fuel under boilers for the generation of steam, for open hearth furnace work, re-heating furnaces, and in a number of cases used in gas engines for the direct generation of power.

Blast furnace gas is used under boilers and in gas engines to furnish air for the blast furnaces and also electric power for outside purposes.

A great deal of experience has been gained by a number of steel plants during the last several years in the generation of steam from boilers, utilizing the heat from the waste gases from open hearth furnaces and re-heating furnaces.

It seems probable that the steel plant of the near future consisting of coke plant furnace, open hearth, and rolling mill departments will be so designed that the several advantages as offered by each phase of heat economy will be so coördinated that no fuel will be burned under boilers direct, and in addition to furnishing all the power required by the plant operation—a fair percentage will be available for sale.

The gas balance in a 500-ton furnace plant is approximately as given in the table below.

500-ton (net) blast furnace—using 2100 pounds coke per ton of pig iron.

Gas per hour, 3,120,000 cubic feet.

Average heat value of gas, 90 b.t.u. per cubic foot.

Boiler efficiency, 75 per cent.

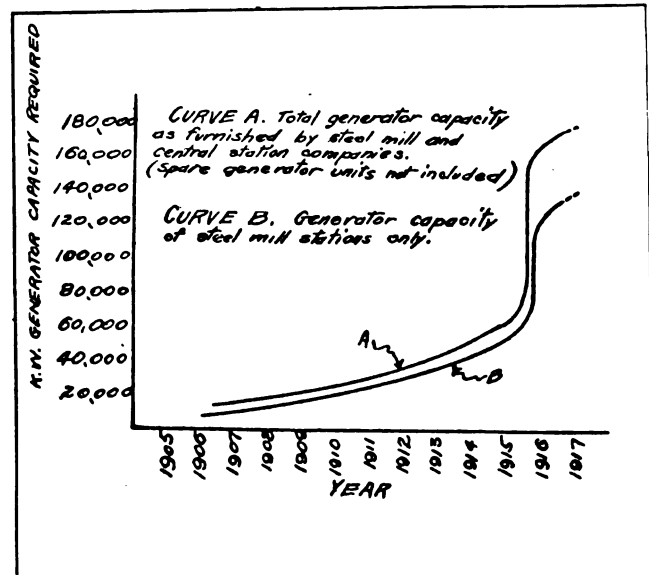


Fig. 4.—Approximate rate of increase of generator capacity required per year for auxiliary motors, main roll motors and electric furnaces—U. S. A.

Gas Balance.		Turbo Blowers Per cent	Gas Engines Per cent
Steam Engines Per cent			
Blowing engines	30.0	14.0	11
Condenser aux.	1.5	2.0	Included in Item No. 1
Other aux.	1.5	1.5	
Cooling water	5.0	4.5	
Stoves	30.0	30.0	30
Tot. required for fur.	68	52	41
Surplus gas	32	48	59

There is so much variation in the conditions existing in different plants that no attempt will be made to work out a concrete case with fixed conditions. It seems more practical to treat the subject in a general way and give comparative data.

	First Cost	Operating Cost
Gas blowing engines—gas engine driven electric units	100%	100%
Gas blowing engines—turbo generators (Complete engine equipments, including auxiliaries.)	60%	80%

These figures are based on modern gas engine units, 4000-kw. capacity and 10000-kw. turbo generators to operate under modern conditions, steam pressure, superheat and vacuum. The same amount of electric power is generated in both cases and coal at \$2.50 fired is to be used to produce the extra steam power by the turbo-generator units.

A considerable further saving in first cost and cost of operation can be obtained by the installation of turbo-blowers in the place of gas engine blowing units, this being approximately 20 per cent and 30 per cent respectively.

Practice shows that 1 kw-hr. of power can be generated for approximately 230 cu. ft. gas by turbo-generator unit and by gas engine unit for 190 cu. ft. It should be noted that a liberal percentage of margin is necessary in estimating the amount of surplus gas available for power purposes, to allow for variation of furnace conditions, and number of furnaces in operation. For a three or four furnace plant this item should be approximately twenty per cent.

A large number of steel plants have adopted the practice of installing waste heat boilers on open hearth furnaces and by a careful analysis of the experience gained in plants during the last seven years many improvements have been devised. Very interesting data is contained in a paper written by Charles J. Bacon and read before the American Iron and Steel Institute, 1915. The following data is taken from this paper:

Approximate statement of savings:

- 1600 to 2,000 pounds steam per ton of ingots.
- 50 to 65 boiler horsepower-hours per ton.
- 65 to 90 boiler horsepower-hours per ton per 1,000 pounds of coal (11000 b.t.u. per lb.) charged in gas produced.

If the open hearth fuel were natural gas, the boilers would generate about 85 per cent as much as with coal, due to less weight of products of combustion.

There is an opportunity for improvement in new installations by means of large boilers and more attention to reducing the heat losses resulting from air leakage and radiation in the regenerative chambers, valves and flues. It is reasonable to expect that the following results can be obtained, though due allowance should be made for average conditions:

- Size of heat—75 tons.
- Time of heat—10 hours.
- Hot metal in charge, 64 per cent.
- Ratio, product to charge, 88 per cent.
- Fuel consumption, 4875 lbs. per hour, or 650 lbs. per ton.
- Heat value of coal, 10,700 b.t.u. per pound.
- Weight waste gases at boiler, 81,400 pounds per hour.
- CO₂ in waste gases at boiler, 12 per cent.
- Temperature waste gases at boiler inlet, 1200 deg. F.
- Temperature waste gases to stack, 500 deg. F.
- Performance of boiler under above conditions, 460 boiler horsepower.
- (150 lbs. steam pressure—100 deg. F. superheat, estimated)

This data shows the wonderful possibilities in fuel economy and the next step is to determine how the steam thus produced can be utilized to the best advantage. In the large majority of cases the greatest amount of work can be performed by generating electric power and using motor-driven mill units.

As a summary of the several factors that warrant the careful consideration of every steel mill engineer regarding the economy of generation and use of power, it may be stated that the general trend of the times is to use waste gases under boilers as fuel or absorb a large portion of their latent heat direct—utilize the steam thus produced in large sized turbines for the generation of electric power and equip the mill universally with motor drive and for the special steel in particular, adopt the electric furnace.

There are many plants which are lacking in such means of economy as have been previously mentioned. Additional electric power means the burning of coal under boilers. As the demands are increasing rapidly the best policy would be to plan improvements on a very comprehensive scale, and will often mean an investment of considerable capital, also more time and attention than the plant management may consider desirable.

The steel mill electric power load is becoming more and more favorable regarding amount, load factor, and power factor, and consequently is more desirable from the central station companies' standpoint. The rates for power and the reliability are features which are attractive to the steel industry and many plants are now purchasing power. At least seventy-five per cent of the electric furnace load is on central station lines and the percentage of main roll motor load is increasing rapidly. The future possibilities of greater benefits to both parties concerned are definitely established by the tendency of the times as given in data of Figure 4.

It is again suggested that more consideration be given to the establishing of a technical data bureau so that a definite analysis can be made for any plant conditions existing or planned for future improvements, for unnecessarily large safety factors, general result in loss of economy, are particularly difficult matters to dispose of in power contracts with seemingly equal equity to both parties. A few such points have been discussed briefly in this paper, but they will only serve to give a rough outline of an engineering policy that would tend toward power economy in any particular plant. The various details of electric power requirements for various types and sizes of mill should be compiled in detail form.

The data previously given shows conclusively that the steel plant electrical requirements are growing much more rapidly than has been experienced in the past—approximately in the ratio of 2½ to 1. The advantages offered are becoming more pronounced each year, and naturally the question of future plant improvements with every mill management who at the present have not elec-

trified their mills, brings up the points—when will they start and to what extent will motor drive be applied? These subjects should, as a rule, be considered jointly, for the actual value of motor drive is seldom realized until it is part of a complete electrification. Thus, a broad engineering policy with responsibility for carrying out a wide plant improvement is worthy of consideration in the majority of mills.

There have been cases where on first analysis the electrification of one new mill only, showed but a moderate return on the investment required. However, when further mill improvements were included in the estimate, the economy of operation was greatly increased. The power station first-cost was materially reduced per unit; the increase of load factor increased the working capacity of a unit of power, thus reducing the proportional cost of station; large size generator units with more uniform load tended towards better economy of operation and existing boiler plants, low economy engines, long pipe lines and various other items which were responsible for high operating costs, could be practically eliminated.

Quite often it is necessary to consider changes upon very short notice and if plans have previously been laid to include the proper improvements, these can be pro-

vided for with less confusion and with the assurance of obtaining the best arrangement.

To show that many plants are planning on just such a broad and comprehensive basis, a review is given of some of the power station installations made recently. The average of seventeen turbine units furnished by the Westinghouse Company to the steel industry within the last eighteen months is 4300 kw. and the largest is 15,000 kw. Such additions to a power plant require considerable time for completion and on account of the urgent demand for additional mills, may prove to be the very factor that would seriously interfere with the adoption of the otherwise favorable plans of electrification. Furthermore, reserve power is an excellent help to caring for the much neglected item—obsolescence of power units. Remarkable advance in central station practice has been made during the last few years along this line. The companies have considered it advisable to prepare for the future on a broad scale and units much larger in capacity and much greater in number have been installed. The advantage of practical engineering foresight which makes possible the planning of several years of future improvements is becoming more and more essential in the development of true economy of operation of every industry.

Elements of Roll Pass Design

General Rules for Roll Pass Design Derived—Passes Should Be Designed for Maximum Reduction Possible Under Circumstances and to Underfill Rather Than to Overfill.

By W. TRINKS.

After preparatory work of previous installments, general rules for roll-pass design can now be derived. The most important rule of all roll-pass design is:

Design the passes for the maximum reduction which is possible under the circumstances.

Carrying this rule into effect means the watching of at least six different variables. Leaving any one out of consideration may result in failure. If success results in spite of such an omission, it does so by good fortune, and not by the forethought of the roll designer. Usually the latter must adapt himself to existing conditions by fitting his design into an existing mill. The reverse process, namely, of having the mill designer build a mill and its drive around the lay-out of the roll designer, occurs in the planning of new mills and is, of course, the ideal of any roll designer. But, as before stated, this case is rare compared to the other, because the number of new installations is limited.

From a strictly scientific standpoint, the right procedure for the design of a roll to fit an existing mill would be to consider all of the variables, say in the following order: We should make sure that the roll

will not break even if the steel is somewhat colder than contemplated. To this end we must know the force which tends to separate the rolls. Fig. 1 gives that force in pounds per square inch of projected areas, for different temperatures and for different speeds of deformation.*

This force should be computed for every pass, and the strength of the roll should be investigated. From

Fig. 2 the bending moment is $M = P \cdot \frac{a \cdot b}{a + b}$, where the reactions are assumed to pass through a point $\frac{1}{4}$ of the length of the neck bearing from the end of

* This diagram differs from the one given by the author in the May, 1915, issue of "The Blast Furnace and Steel Plant," in that the statement was made that the excess force necessary to deform steel is directly proportional to the velocity of deformation. This statement was correct and is still correct as long as the steel maintains the same physical properties under the increased stress. But partial liquefaction occurs under the higher stress so that the excess stress follows the straight line law for a limited range only and then tapers off toward a maximum, which latter equals the pressure required for liquefaction of the steel at the given temperature. It may be remarked that H and h (Fig. 1) are the thicknesses of steel before and after the pass, and that T is the time in seconds during which the roll passes through the arc of contact between steel and rolls.

bearing nearest the roll, on account of the deflection or "spring" of the roll.

The stress follows from $S = \frac{M}{Z}$, where Z is the section modulus. For steel the section modulus is $1/10 d^3$, but for cast iron it is $1/5 d^3$, on account of the curved stress-deformation relation of that material which causes the inferior fibres to carry more stress

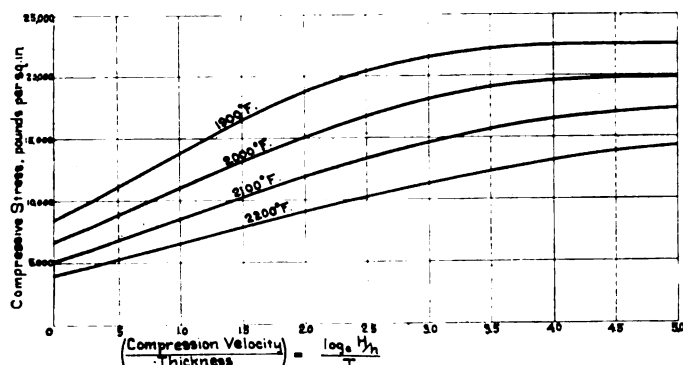


Fig. 1.—Unit pressure between steel and rolls.

than Hooke's law of proportional deformations assumes. For ordinary rolling temperature the factor of safety should be three, which means that the roll is stressed to the breaking point if the temperature of the steel is allowed to drop about 350 deg. F. below the correct value. For steel rolls the yield point stress must not be exceeded, except very occasionally. The yield point depends upon the quality of the steel and ranges from 40,000 pounds per sq. in. for cast high carbon steel to 75,000 pounds per sq. in. for forged nickel steel rolls. For cast iron (sand) rolls the limiting stress is 25,000 to 28,000 pounds per sq. in.

In Fig. 2 a V-shaped pass was shown on purpose. A notch of this type weakens the roll perceptibly, depending upon the fillet at the bottom of the notch. The factor by which the stress obtained from the formula $S = \frac{M}{Z}$ must be multiplied to obtain the true stress

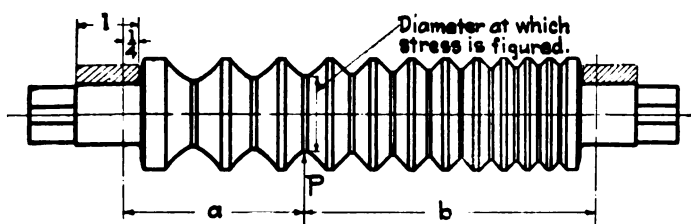


Fig. 2.—Illustrations showing dimensions necessary to adapt roll pass to strength of roll.

at the root of the fillet may roughly be taken from the following tabulation:

Radius of fillet	0.00	$\frac{1}{4}$ "	$\frac{1}{2}$ "	1" or over
Magnification factor ..	10	3	2	$1\frac{1}{2}$ or over

Very few roll-pass designers have the necessary mathematical implements to carry out such a calculation, and those who have the implements make the

calculations for very few rolls, depending upon the results of such calculations and of experience to guide them in all other work. Nevertheless, young engineers should not grudge the tedious work of performing several of these calculations, because they can, in that way, acquire the same judgment which, without them, can only be acquired by long experience.

If the rolls are very short, having, for instance, only one pass, as in continuous mills, another feature enters, namely, the twisting strength of the rolls. The effective lever arm of the separating force is approximately $.7E$, see Fig. 3. The twisting moment on the roll is then $.7E \times \text{projected area} \times \text{pressure}$ (from Fig. 1) = M_t . To this moment must be added the roll neck friction moment which, for small rolls and good lubrication, equals 50 per cent of the torque M_t and which, for large rolls and poor lubrication, runs up to 250 per cent of M_t . "Small rolls" means that (average roll diameter / average thickness of steel) is $2\frac{1}{2}$ or less. "Large rolls" means that the same ratio equals 40 or more. For actual conditions, the designer must "guesstimate" between the two.

The sum of these moments, namely, steel compres-

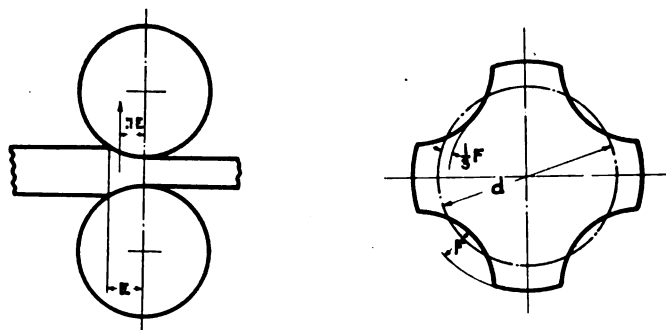


Fig. 3.—Location of resultant force between steel and roller.
Fig. 4.—Size of circle having the same torsional section modulus as wobbler.

sion moment plus neck friction moment (plus friction moment of steel in rolls, if such moment exists) must be transmitted through the wobbler, the section modulus of which is $1/5 d^3$. The meaning of d is clear from Fig. 4.

It goes almost without saying that the total torque must not exceed the capacity of the mill pinions and of the drive, motor or engine. Likewise it is clear that the reduction must not endanger the strength of the mill housing.

The reduction is also limited by the friction angle (α , Fig. 5). It is well known that for smooth rolls the angle must not exceed 22 deg.; that for rough rolls it must not exceed 30 deg. and that for ragged or corrugated rolls it must not exceed 36 deg. With fast rolling, the angle must be kept small, unless the material is delivered to the roll at almost the peripheral speed of the latter.

Reduction is, therefore, limited by wear of the

rolls. It has repeatedly been pointed out in these columns that the steel leaves the rolls faster than it enters, that the peripheral speed of the rolls is constant, and that, consequently, there must be slipping or creep between steel and rolls, with attendant wear of the latter. In addition, wear occurs on account of the difference in linear speed at different radial distances from the roll axis. The colder the steel and the greater the reduction, the greater is the wear. From these facts follows the rule that in the finishing pass and in the pass preceding it the reduction must be small. In finishing passes the reduction seldom exceeds 5 or 6 per cent. If it does, several finishing passes are provided so that a new one may be used after the preceding one has been worn too much.

Last, but not least, the permissible reduction depends upon the strength of the steel with regard to deformability in the presence of tension. This feature

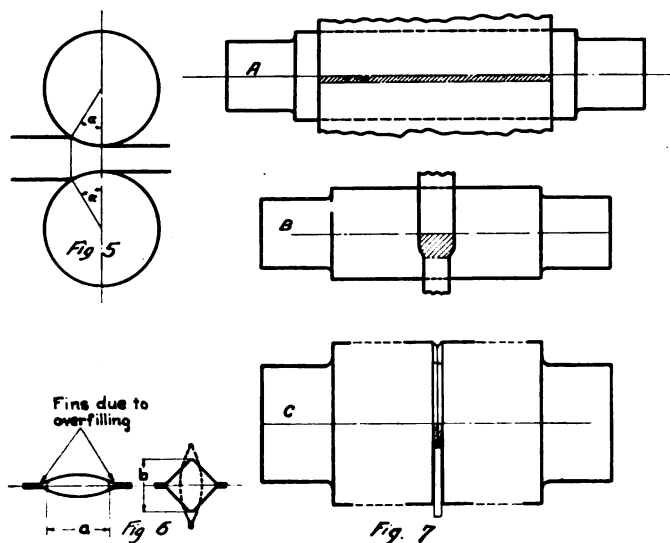


Fig. 5.—Limiting angle for gripping steel—Fig. 6.—Fins caused by overfilling of pass—Fig. 7.—Shape of projected contact area for different passes.

was explained in the June (1917) issue, and was further illustrated in the September issue. For a high quality steel the limit of deformation is practically never reached. With the average run of steel, limits are reached. This has led to the rules that, in flat passes, the angle α of Fig. 5 must not exceed 30 deg. for very fast rolling, and must not exceed 36 deg. for slow rolling, also that, for rectangular sections, the reduction in one pass should not exceed 60 per cent. For other shapes of passes the limiting feature caused by the tearing of the steel will be studied when those shapes come under discussion.

After the maximum reductions have been determined, the second general rule enters into action:

All passes must be so designed that they underfill rather than overfill.

If a pass does not quite fill, little harm is done unless it be the finishing pass. If a pass overfills, see

Fig. 6, a fin is formed which cools and scales on its surface. The fin is rolled back into the bar in the next pass, but never unites with the rest of the steel. Occasionally it is pushed back bodily, but more often it laps over, producing surface cracks in either case. Underfilling causes no harm, because the bar is turned 90 degrees after every few passes and is thus "sized," which means that the resulting dimension a in Fig. 6 is rather immaterial, because it is brought to "size" or dimension b in the next pass. To prevent overfilling, it is necessary to know approximately the rate of spreading. In the July installment, attention was called to the fact that the ratio of spreading to draft depends principally upon the shape of the projected contact area. If the latter be short and wide (case A, Fig. 7) there is no spreading. If it be nearly square (case B, Fig. 7), the spreading equals 40 per cent of the draft, and if it be long and narrow, (case C, Fig. 7), spreading may exceed 50 per cent of the draft.

These data suffice to design passes without overfilling. To make doubly sure that there will be no fins, we can shape each pass so that the material is given "extra spreading room" at the place where a fin

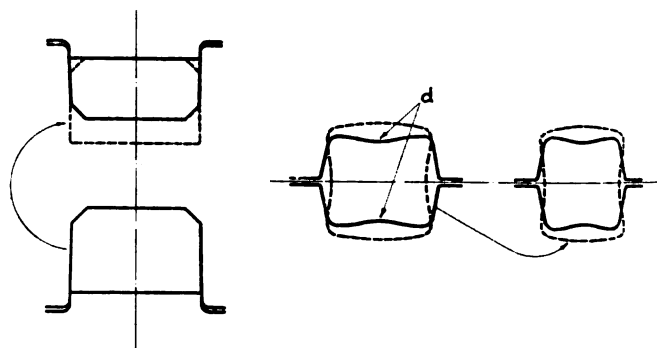


Fig. 8.—Reduction of thickness in center to prevent overfilling in succeeding pass—Fig. 9.—Method of preventing fins when rolling flat in closed passes.

could form in the following pass. Two examples will illustrate this expedient. In open passes in blooming mills and billet mills a slight depression is frequently used as indicated at points d in Fig. 8. In the succeeding pass the bloom or billet is turned 90 deg., (as indicated by dotted lines). The narrow waist allows considerable spreading without the formation of a fin. In the rolling of flats in closed passes of three-high mills the corner at the bottom of the pass is broken, or a very large fillet is put in, in the roughing rolls, see Fig. 9, upper half. In the next pass (lower half of same illustration), the chamfered edge (see dotted lines), is a safe distance away from the split, and no fin results.

Up to the present, considerations have been rather general. In the next installment a complete example, utilizing all of the theoretical information, will be given.

Electric Furnace Central Station Supply

Central Station Anticipating Electric Furnace Business Should Prepare to Discuss the Electrical and Metallurgical Characteristics of Various Types of Furnaces With the Buyer.

By EDWIN L. CROSBY.

Probably no instrument for the use of electrical energy for industrial purposes, other than the induction motor, has caused as much interest among both central-station operators and their patrons as the electric furnace, particularly in its application to the steel industry. Arriving as it did to that state of development which allowed its installation as an economically practical piece of apparatus simultaneously with an unprecedented demand for the very materials to the production of which it was most suitably adapted, the electric steel furnace has come in for very exhaustive consideration by the various individuals, manufacturing companies and societies interested in the production or sale of either steel castings, electric steel furnaces, or electrical energy.

Up to the present time approximately 200 steel furnaces of various types having an annual capacity of about 1,200,000 tons of steel have been installed or contracted for on this continent. This steel production involves the use of approximately 750,000,000 kilowatt-hours per year. This is the very healthy interest of the aggressive central station man in the problem justified.

Errors Have Been Made.

Naturally in the attempt to secure all the new business possible by the use of electric furnaces, many concerns both in the steel casting trade and central station business have made serious errors. Many steelmakers and foundrymen have installed furnaces which for various reasons were utterly unsuitable for their use. Also many central stations have listened to the luring tales of various highly estimable furnace salesmen and permitted, even urged, the connection of furnaces to their lines, the operation of which was fatal to the happiness and peace of mind of the entire production department of the stations concerned. Beautiful visions of regulation equivalent to that of a lighting load, perfect phase balance et cetera have become nightmares of despair to not a few of the power companies of the country. Others have quoted rates for this class of service inconsistent with the characteristics of the load with rather disastrous results to their balance sheet.

To avoid unnecessary repetition of such occurrences it is essential that a closer study of the adaptability and operating characteristics of electric furnaces in general and the more common types of steel furnaces in particular be made by foundrymen contemplating the installation of such apparatus as well as by the central

stations from which the foundrymen are likely to purchase power.

Has a Right to Advice.

Any foundryman has a right to expect intelligent advice from his local central station on the electrical characteristics, their advantages or disadvantages, of any electrical equipment he may contemplate purchasing.

Central stations certainly stand ready to advise a storekeeper as to the best form of lighting equipment for him to use; they also are prepared to tell the power consumer which type of motor is best fitted for the particular purpose under consideration. An aggressive, wide-awake central station engineer is even able to advise intelligently upon problems involving various types of refrigeration equipment, valve gear, or air compressors, etc., giving due consideration to their effect on the customer's "demand," energy consumption, etc., and the consequent rate he would earn.

By the same token, the central station anticipating electric-furnace business should be prepared to discuss intelligently with the buyer of an electric furnace the electrical and metallurgical characteristics of the various types offered for sale. The power salesman must have a fairly good understanding of the metallurgical practice involved before he is able to give dependable data on the electrical performance of any furnace as these two matters are very closely related. For instance, an electric steel furnace connected to a large power system capable of handling large blocks of energy may be operated with less regard to fluctuating power input than if it were connected to a system of which constituted a large proportion of the total load.

Take a specific case—melting and refining cold scrap for small steel castings. The only limiting factor in the rate of current input during the melting period seems to be the effect upon the customer's demand. The scrap has an infinite capacity for absorbing heat, the refractories will not be injured, the radiation losses per heat are decreased and the electrical equipment, if properly designed, can stand considerable overload during this period, if it is really desirable to increase the rate of energy input. When refining, however, a much lower rate of heat, hence energy, input may be desired, perhaps only that rate necessary to maintain the temperature already acquired until sufficient time has elapsed for the desired chemical reactions to occur. It would seem, therefore, desirable to operate with a much higher arc voltage during the melting period, decreasing the

Paper read before the American Foundrymen's Association, Boston, September, 1917.

potential when the bath becomes fluid and refining is begun. It is entirely possible that such a method may result in a lower cost of power per ton. Quite certainly it would result in a lower current consumption per ton and if carefully controlled, an extra heat per day is easily obtained. Balanced against the increased demand charge per ton of metal are lower overhead charges, lower labor charges, lower radiation and electrical losses and general increased operating efficiency.

Coöperation Is Needed.

Here is where it is quite necessary for the central station man to assist the furnace user in determining the most economical point for operation. The method of determining demand and greater current fluctuations upon the distribution system are important factors in the determination of this point, and require a fair degree of familiarity with electric-furnace practice as well as with the central-station rate schedule.

In this connection, it is the writer's sincere belief that there is considerable opportunity for standardization of demands by the central stations of the country. It does not seem reasonable that local conditions are sufficiently diverse to account for the extremely variant methods now employed by companies selling service under relatively similar conditions.

While the cost of power per ton of steel produced is of course important, being one of the greatest tangible items in the cost sheet, the writer has visited several electric-furnace installations where power cost seemed to be paramount issue, while in reality a lack of superintendence and generally loose organization ran up charges far in excess of any reasonable power cost. As a matter of fact, industry in general is rapidly awakening to the fact that with the present greatly increased cost of labor and material together with a very slight (if any) increased cost for electricity, the power cost of most any article manufactured is not as important as formerly was the case.

Heretofore, the greatest item for consideration among central stations desiring an electric-furnace load has been the power factor. There is no occasion for unrest upon this point at the present time, as very careful investigation of several furnaces of various types has shown that with the possible exception of one type of arc furnace, and the certain exception of the induction furnace, all steel furnaces on the market to-day, if properly installed, will operate with a power factor of 0.80 to 0.85 during the early stage of the melting period, later rising to 0.85 to 0.90, and finally to a point as high as 0.95 or better during the refining period.

May Have a Leading Power Factor.

Inasmuch as single-phase arc furnaces should never be connected to polyphase systems except through phase converters, while induction furnaces operate more satisfactorily at frequencies below those in general use, thus requiring frequency changers, either of these types, thus

equipped, may be connected to a polyphase system so as to impose unity or even a leading power factor.

Regulation, phase balance and wave distortion have not, on the other hand, received the attention they undoubtedly deserve. Present electrode regulation is at the best very unsatisfactory, it being impossible with any existing equipment to obtain sensitive regulation without considerable hunting of electrodes and disturbance of phase balance. If it is proposed to connect an electric furnace to a net work properly designed to satisfactorily operate under existing conditions and with existing load, very careful consideration should be given to this point of regulation, and it may be advisable that carefully selected reactances be placed in the furnace circuit.

Recent oscillographic investigations have shown a very marked distortion of the current wave in all types of arc furnaces. This subject is a very important one as it may affect the accuracy of induction type watt-hour meters. Large wave distortion is also detrimental to the operation of other apparatus connected to the system, for instance, lowering the efficiency of rotary converters.

At first thought it may seem that such subjects are irrelevant before a foundrymen's meeting, but the writer wishes to call attention to the fact that it is necessary for a public utility serving any particular class of business to charge back to that class any expense contingent upon the service; so that if in order to superpose upon existing systems, satisfactorily operating any new form of load, it becomes necessary to increase the investment to an abnormal point, that investment must be reflected in the rate charged for the new class of business.

The writer does not wish to pose as an alarmist, nor does he believe that in the large majority of cases any such fears need be serious deterrents, but when a central station operating a transmission system of considerable length with somewhat limited capacity in generating and distributing equipment connected, attempts to take electric-furnace business, especially at rates based upon existing conditions, it is quite likely to get into serious difficulty which may later cause the station, as well as the furnace user, deep regret.

Should Offer Unprejudiced Opinions.

For the reasons mentioned it is obvious that the representative of a central station anticipating electric furnace business, should thoroughly familiarize himself not only with the operating characteristics of various types of electric furnaces, but also with his customers' requirements, and after careful consideration should offer an unprejudiced opinion upon the relative desirability of the various furnaces obtainable. It may be good judgment to advise against the electric furnace installation entirely. This was the writer's experience upon two occasions recently. Two customers having more or less scrap to sell and experiencing the universal difficulties in steel deliveries contemplated the installation of electric furnaces to supply their demands. After considering the

investment, delivery on furnace and electrical equipment, the uncertainty of the market both during and after the war, the customer in each case was unhesitatingly advised not to make the installation. Incidentally, I believe any central station which urges the installation of electric furnaces for steel based upon the present market may later have cause for regret, unless it receives a rate commensurate with the risk.

The central station and the steel manufacturer have to consider from different standpoints the conditions peculiar to the present time, in deciding whether the investment in an electric furnace or the investment in the power plant and transmission necessary to supply that electric furnace should or should not be made. The steel manufacturer may be able to recover his entire investment by the sale of his output at high prices in a war time market which cannot get enough high-grade steel, whereas the central station is required by financial methods, and in some cases by law, to treat all of its investments as permanent, or if not permanent to be amortized over a long period of time, and is further required to have its rates for all classes of service consistent with one another. Therefore, the central station is compelled to consider the future of the steel market, the permanency of the service and the possibility of selling its capacity to some other industry in case the steel furnace should cease to be profitable to the manufacturer after the normal market conditions are restored.

Perhaps the demand for high-grade alloy steel for new uses after the war will keep all the electric furnaces busy. Perhaps the increased cost of labor and fuel will operate against the open-hearth or other less efficient processes sufficiently to allow the electric furnace to compete in ordinary tonnage production. The central station certainly hopes so. But meanwhile any installation should be carefully considered.

Such advice at this time is perhaps superfluous, as it is doubtful whether deliveries on electric furnace equipment are attractive enough to cause any great interest. **Should Compete Successfully.**

As stated in the report of the electric steel furnace committee to the National Electric Light Association this year, that body believes that the electric furnace should supplant or successfully compete with the crucible or converter processes for any purpose. It should, given usual freight differentials, supply local markets with the equivalent of the higher grade open hearth material, local scrap markets being favorable. However, under normal conditions the committee did not feel that the electric furnace was a competitor in tonnage steel.

In the steel casting trade there appears to be no reason why the electric furnace, when thoroughly developed, should not supplant practically all other methods in foundry use. By close coöperation between foundrymen and the central station people that development can quickly be carried to completion. We may reasonably hope to realize that long anticipated ideal which I once

heard stated at a meeting of this society by a representative of a competitor of the electric furnace, namely: "The electric furnace method is the ideal method for making ideal steel." The central station is willing to do its part.

Report of Coke Oven Accidents in 1916.

Reports received from the operators of coke ovens show a slight increase in the number of fatalities and injuries during the year 1916 as compared with 1915. The number of men killed in 1916 was 45, as compared with 38 in 1915 and 45 in 1914. The total number of men reported employed for 1916 was 31,603, as compared with 31,060 in 1915. The fatality rate in 1915 (based on the number of 300-day workers) was 1.21 per 1,000; in 1916 it was 1.32. The injury rate in 1915 was 90.78 per 1,000 men employed; in 1916 it was 153.49.

The reports represent 68,796 ovens in operation, as compared with 55,112 in 1915. The average number of days active in 1916 was 324, as compared with 303 in 1915 and 286 in 1914. The accident figures thus collected may not be complete for the entire industry, but they are sufficiently representative to point out some of the principal hazards.

This data is included in the second report published by the Bureau of Mines giving separate accident data for beehive and by-product ovens and indicating a greater hazard for the latter than the former. In the bureau's previous report relating to accidents at coke ovens all fatality and injury rates were based on the number of men reported as employed. As all the plants do not operate the same number of days, all of the labor and accidents data submitted have been reduced to the equivalent of 300-day workers. A summary of the bureau's reports for 1913, 1914 and 1915 is included, which has also been reduced to the same basis, thus making possible true comparisons one year with another and also one State with another.

Many of the States now have compensation laws, and in order to conform with their classifications the bureau's classification of serious and slight injuries are on a 14-day (two-week) basis. The classification of injuries for 1916 is as follows:

Classification of Injuries for 1916

	No. Injured
1—Fatal	45
2—Serious (time lost, more than 14 days):	
(a) Permanent disability—	
Total	2
Partial	81
(b) Others	686
3—Slight (time lost, 1 to 14 days, inclusive)...	4,468

Permanent Total Disability.—Loss of both legs or arms, one leg and one arm, total loss of eyesight, paralysis or other condition permanently incapacitating workman. Permanent Partial Disability.—Loss of one foot, leg, hand, eye, one or more fingers, one or more toes, any dislocation where ligaments are severed, or any other permanent injury.

PRODUCTION TOPICS

OPEN HEARTH SHIELD.

An improved tapping hole shield for use on open hearth furnaces has been developed by C. L. Kinney, superintendent of No. 1 open hearth department of the Illinois Steel Company, south works. The shield, to be known as the "Kinney tapping hole shield," is being used instead of the Conway shield, which only partly covered the tapping hole. It is attached to the furnace by belting an angle iron to a buckstay on each side of the furnace spout and is operated by pulleys and a weight. The shield consists of a plate to which is attached a curtain of short chains, made of $\frac{3}{4}$ -in. links, made to fit the size of the tapping hole. Its purpose is to protect the helpers from a puncture tap while roding out. The device was also tried on a blast furnace during the operation of "flushing" a furnace but did not prove as practicable for

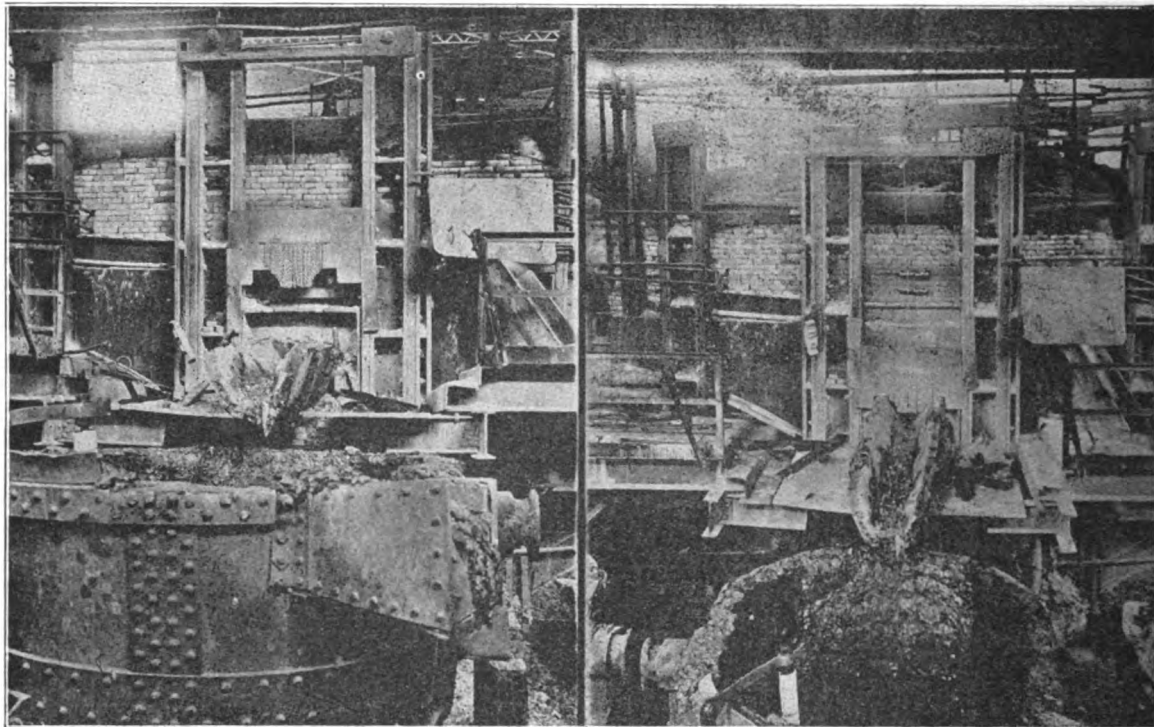
fore and after it has entered and left the mould. The essential part in the working of steel in the Bessemer or open hearth is the temperature upon entering the moulds, (the casting temperature), this temperature ranges very little between the Bessemer steel and the open hearth steel, in actual practice will not vary more than 40 deg. to 50 deg. C. These temperatures may vary to this extent without any noticeable effect in rail steel practice where the steel is poured through a 2-in. or $2\frac{1}{2}$ -in. nozzle directly into the tops of the moulds so long as the temperature is not low enough to cause a "skull" in the ladle, coking off the nozzle and causing a top pour.

When drillings are taken from a broken rail and the chemical analysis is determined and the chemical properties are not exceedingly high, the fact of putting the blame on the chemical elements is not correct, as it is only a coincidence

and more than likely the breakage is due to the treatment of the steel before entering the moulds or in the soaking pits before or while rolling.

In the open hearth practice it is an easy matter to judge what the temperature is like when the steel is tapped from the furnace into the ladle, and the variation of a few degrees may pass unnoticed in ordinary practice, but where bottom cast steel is made it is absolutely necessary that the temperature is very closely watched and a good tem-

perature is maintained as too low a degree of temperature will cause the steel to pour slow and cause lappiness or folds in the ingots, and conditions very often will arise where the ingots will not fill or will pour to uneven sizes where they are poured in groups of eight to twelve at a time. Steel containing chromium or high in silicon will present this condition to a certain extent more readily than ordinary low carbon steel. The filling of a group of bottom cast ingots will give a very forcible idea of the casting temperature and it is more apparent here than in any other method of pouring. The variations in casting temperatures and the manner of teeming adds materially to the production of sound ingots. The silicon and manganese has also a great influence upon the soundness of the ingot as well as the aluminum used in the moulds while casting.



Kinney tapping hole shield—The illustration on the left shows the shield in place over the tapping hole rendering it almost impossible for a helper to be burned when the device is in this position. On the right the shield is shown hoisted when not in use after the hole has been dug out.

this purpose as the old solid shield. The accompanying illustration shows the shield both in working position over the tapping hole, and hoisted when not in use after the hole has been dug out.

TEMPERATURE INFLUENCE ON STEEL INGOTS.

By J. W. Haulman.

Sound ingots in the manufacture of steel for rails and other structures upon which the safety of the public depends is a matter of great importance. Different types of moulds have been tried, including the Hadfield and Gathmann. Hot top ingot brick have been put on the market by reputable brick manufacturers. All this has been done to accomplish one very essential feature, i.e. a sound ingot. All this will not, however, overcome the improper treatment of steel be-

PRODUCTION TOPICS

Too high a temperature when casting into the moulds renders the metal wild and favors the formation of blow holes these blow holes are narrow and elongated closely on each other, and the more of these caused by high temperature causes the steel to be weak and it will crack badly in rolling. High temperature puts CO and CO₂ into the steel, and when spiegel is used for recarburizing in the molten form with this high temperature more carbon in the spiegel reaction oxidizes and forms CO and CO₂, which also forms more blow holes. The spiegel reaction is more violent in a hot heat than one of milder temperature. The formation of these blow holes makes the steel crack badly when rolling. Catching the steel young in the Bessemer converter gives a very weak reaction with spiegel and makes a weak steel, unless there is a sufficient time to thoroughly soak the steel in the heating furnaces.

There are two classes of gases in ingots—mould gas—CO, CO₂ and H. The hydrogen is less harmful. Free oxygen which gives very similar blow holes and can be readily detected causes the steel to red short.

Too young a blow in the converter often tends to produce such a weak reaction that the free oxygen gets into the steel and causes cracking. Hydrogen gas is considered not harmful and this has been proven to satisfaction that low silicon steel works better than high silicon, because low silicon steel is porous and the gases work out better healing up the blow holes before the steel solidifies.

Hot blowing is not desirable as there is more silicon in the blown metal than a good temperature, especially where a high silicon iron is used and unless this is scrapped with exceedingly good judgement wild metal will be produced which will cause unsound ingots. Hot heats will result in a very dangerous element—in that they produce segregation and hence a weak steel.

It is claimed and known to be a fact that when an ingot goes into the heating furnace it should be heated in such a manner that when it comes out of the furnace it should have a nice jacket of scale. A .45 to .70 carbon steel will not stand a cutting heat, that is, it will not do to run the slag as by this continual high temperature, the ingot keeps oxidizing and finally the thin skin over or under which the blow holes are concealed is eaten away and the blow holes are exposed, and it is rolled out with small specks or three cornered flaws, which will invariably come along the flange or head of the rail which will be discarded as a second quality or if too prominent the rail will be thrown out as scrap. This can be counteracted when an ingot has a good jacket of scale on, when it comes out of the heating furnace and no spots where the slag has continually run exposed the blow holes. In a low silicon steel the skin over the blow holes is thicker or the blow holes are nearer the center of the ingot and the gases work out through this porous mass in rolling, (probably the top of the ingot). Steel always rolls good when a greenish flame comes off it while going through the rolls, which is believed to be a union between the decomposed H₂O and the gases out of the steel.

The heating of an ingot to a certain temperature and rolled to a certain finishing temperature gives a fine grain and a physically perfect bar. If heated above this certain temperature the final structure will crystallize and breakage is bound to occur.

GUN FOR DIGGING SLAG FROM OPEN HEARTH.

The Rivet Gun Cutting Company, of Cincinnati, Ohio, has recently placed on the market a gun for digging slag from open hearth slag pockets—doing away with the necessity for any skilled labor, as well as reducing labor costs—doing away with the sledge hammer and bar, the operator, by its use, striking a blow many times harder than it is possible with a sledge and fifty times as fast.

This is accomplished by an eight pound piston and a twenty-six inch stroke reciprocated by air pressure. The course of the air entering the gun via the air intake located at the top of the tool is controlled by the operator at the three way valve near the air intake port. At the option of the operator it is possible to deliver either a very light stroke or a terrifically hard blow. The value of this feature is very apparent to anyone familiar with the requirements of a practical tool for digging slag. The construction of the tool is of material which long usage and good mechanical practise have demonstrated to be the best. There are no complicated parts to get out of order though the tool is



Use of gun in cleaning out slag pockets of open hearth furnace

manufactured to close standards thus making all parts interchangeable. The force of the blow is cushioned by patented features which not only tend to make the tool stand up under severe conditions, but furthermore, entirely overcome the disagreeable features so common in air tools to "kick the operator." Air pressure of seventy-five pounds and up is used for the best results.

NEWS OF THE PLANTS

A. I. S. E. E. MEETINGS.

On Saturday, November 24, the Pittsburgh district section and Cleveland district section of the A. I. S. E. E. will hold a meeting at the Cortland House, in Canton, O. Several steel mills in Canton will be inspected by the members attending the joint session. Central station power and electric furnaces will be discussed at the technical sessions.

At the last Cleveland section meeting of the A. I. S. E. E., held in Cleveland, October 13, 1917, Ralph D. Nye read a paper on electric drives for blooming mills.

The Pittsburgh section of the A. I. S. E. E. held a meeting October 20, at which Ward Harrison, of the Nela Park works, General Electric Company, Cleveland, read a paper on recent lighting equipment in the steel mill industry.

The next meeting of the Pittsburgh A. I. S. E. E. will be held in Youngstown, O., on the third Saturday in December.

STEEL MILLS SUPPORT LIBERTY LOAN.

The accompanying illustration of the enthusiastic support given by the men at the Bethlehem steel works, shows that the steel industry is not only contributing its share as an industry engaged in turning out munitions, but also is providing funds for Liberty Loan bonds.

The illustration shows a publicity board at one of the



Scene at one of the Bethlehem plants during Liberty Loan campaign.

plants of the Bethlehem Steel Company. It shows the score board, clock and thermometer which registered the results of each day's work. There are about 69,874 employees at the various plants of the Bethlehem Steel Company and 94.3 per cent subscribed \$5,770,650 to the first Liberty Loan.

The Marietta furnace, Marietta, Pa., operated by E. J. Lavino & Company, Bullitt building, Philadelphia, has recently commenced the production of ferromanganese.

The Old Forge Landing Iron & Steel Company, St. Louis, Mo., has recently been incorporated with a capital of \$500,000 under Delaware laws, to operate an iron and steel plant, with rolling mills and allied structures. W. C. Kitchin, R. O. Smith, and J. C. Pratt, St. Louis, are the incorporators.

The Hess Steel Corporation, Loney's Land and Biddle street, Baltimore, Md., is planning for the erection of a new electric furnace and other structures. H. L. Hess is president.

The A. M. Byers Company, manufacturer of wrought iron pipe, has resumed operations at its local puddling mills, which have recently been closed to allow extensive improvements for increased output.

The Fulton Steel Company, Fulton, N. Y., has filed articles of incorporation with a capital of \$120,000, to manufacture iron and steel products. The incorporators are H. W. McAteer, G. C. Warner and C. W. Elhany, 233 Broadway, New York.

The Atlas Crucible Steel Company, Howard avenue, Dunkirk, N. Y., manufacturer of crucible tool steel, is planning for the construction of a new rolling mill, machine shop, transformer station, and other structures, to increase its capacity.

The Nagle Steel Company, Pottstown, Pa., is making rapid progress in the rebuilding of the former rolling mill plant at Seyfert, recently acquired. The plant will be remodeled and equipped for a steel and plate mill, specializing in the production of steel plates. The installation will consist of rolls, tables, sheet-making machinery, and other apparatus.

The Warwick Steel & Iron Breaking Company, Warwick, Pa., has been organized to operate a local scrap iron plant. The works will be used for the breaking and scrapping of large pieces of iron and steel. Main offices will be in the Harrison building, Philadelphia. Frank Dallet, F. A. Dutton, and C. C. Bland, are the incorporators.

Owing to difficulty in securing coal, the Central Iron & Steel Company, Harrisburg, Pa., has installed blowers at its plant to allow the use of river coal almost exclusively. By forced draught it is expected to derive greater efficiency from this type of fuel.

The National Castings Company, Marietta, Pa., recently organized, has commenced operations at its foundry for the production of high grade iron and steel castings. The company's works comprises the property formerly occupied by the Marietta Manufacturing Company.

The Tacony Ordnance Company, Philadelphia, Pa., recently organized, is having plans prepared for a series of shop buildings to comprise its initial works in the Tacony section. The structures will include a one-story machine shop, 129 x 270 feet; one-story forge shop, 140 x 335 feet; open hearth shop, 125 x 200 feet; and heat treatment shop, 125 x 200 feet. The new plant will be devoted to the production of forgings for heavy artillery, including rough machining work of the different parts. The equipment will include two 50-ton open hearth furnaces, hydraulic apparatus, 21 cranes and other machinery; a 60-ton ladle crane will be installed for handling the forgings in oil baths. It is said that equipment will be purchased immediately. It is expected to have the plant in full operation by the first of the year. George Satterthwaite is vice president and general manager. Thomas B. Lippincott is architect.

INDUSTRIAL SAFETY

OPEN HEARTH HAZARDS.

By Leslie M. Rice.

While improved practice has gradually developed safer and more efficient equipment for the manipulation of an open hearth plant in the various cycles of its operation, and while we may assume that all ordinary mechanical means of eliminating hazards have been installed, there still remains some occasions where an accident develops the need of another mechanical device due to peculiar conditions existing in the plant. In addition to which the real cause of accidents still remains well entrenched, namely, the problem of indelibly stamping upon the minds of the operating force the necessity of observing the first natural law, that of self-preservation and of inculcating mental habits that will lead them to consider the proper way to approach their jobs. The methods employed by some men in performing work which could be done with absolute safety to themselves and their fellow men, cause an observer to wonder if they possess the instinct of self-preservation. Experience has taught us that the accident problem must be approached from two angles, protection through mechanical safety devices, and educational measures. By mechanical safety devices, we mean guarding exposed gears in moving machinery, covering against contact all live parts of electrical equipment, providing railings and platforms where necessary, and the like. By educational measures, we mean methods of studying accidents, ways of interesting the workman in the safety movement, and making him realize his share of the responsibility in developing safe working practice.

While the matter of mechanical guards is now pretty well standardized, it may be interesting to touch briefly upon several of the hazards of open hearth practice that can and have been removed by mechanical safety devices.

The hazards of railroad crossings are more easily eradicated in new construction where it is possible to arrange the buildings with this matter in mind. However, existing installations can be made much safer in many instances by installing stairways under or over the tracks and changing the location of storage bins. Exposed gears and overhanging gears on cranes should be protected, and cranes should have runways suitably designed, both on the crane and building, for there are occasions which arise during the course of the usual operations of handling hot metal when some part of the equipment shows symptoms of failure, and quick action is demanded of the operator or mechanic to avoid serious consequences.

The handling of the furnace through the cycle of its various operations carries numerous hazards, practically all of which can be eliminated with a little forethought. For instance, the tapping hole of the stationary type of furnace, more particularly in the basic heats, is occasionally opened up by the action of the metal from the inside, due to faulty workmanship or material, before the heat is ready, or the operator ready to receive it. Very serious consequences may result if the metal reaches a sewer or damp place on the floor. To avoid such contingencies, the ladle ready to receive the heat should be set in position on suitable stationary horses very shortly after the charge is melted.

The operators of the hot metal electric cranes should be educated to inspect the crane parts, and especially the ef-

iciency of the brakes previous to the handling of a heat. The brake should be tested by trying it out with the empty ladle hanging on the crane, and later examining the brake. Failure of the electrical current during the progress of heat may make it vitally important that the brakes be in good condition.

The controlling valves for gas and steam lines located in front of the furnace are commonly uncovered; numerous instances have occurred where they were broken by being struck during the course of repairs or charging operation by the crane or charger, resulting in severe burns to some of the workmen. They should be covered. Charger operators should have a protective shield to prevent burning by sparks thrown from the furnace where damp or frozen stock is dumped into molten slag or metal. Even in the best practices bottom blowouts will occasionally occur and if they are not well handled, serious accidents may result. The men should be drilled to their parts in handling the situation as they would be schooled for a fire drill.

Stockyard Hazards.

It is obvious that good housekeeping is one of the best antidotes for accidents in the stockyard. Clean trackage leaves nothing to trip over in front of a moving train; sufficient clearance between tracks and piled material eliminates the possibility of squeezing some of the stockers. Stock properly piled materially aids in maintaining an orderly appearance, and assists in handling the material with less hand labor which in itself is a source of numerous injuries arising out of being forced to work in awkward positions.

Protection for the Switching Crew.

Good equipment with such mechanical protection as running boards, hand rails, pilot cars, automatic couplers, etc., maintained in good condition, still leaves the organization to contend with most of the accidents incident to railroad transportation service, such as those arising from men mounting the running board of an approaching engine from the track, and entering buildings without the switchmen piloting the train as an additional warning, besides bells or whistle to make sure that the tracks are cleared.

Fuel Hazards.

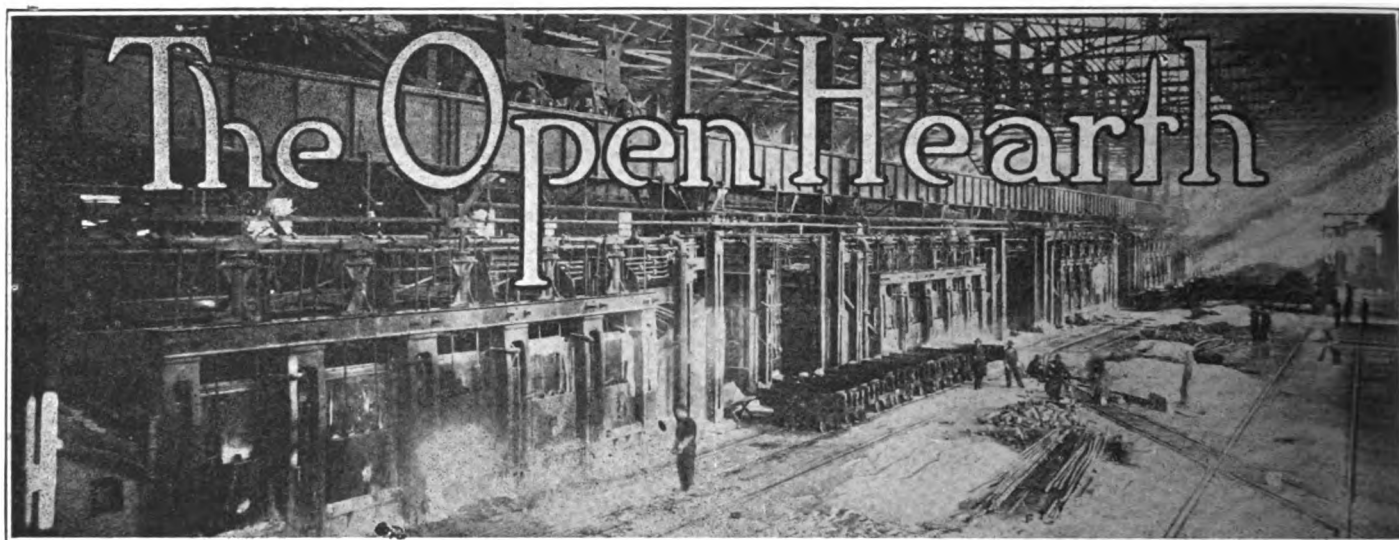
As might be surmised, a perusal of the accident records reveals numerous cases arising out of steam burns, back fires from coal gas and fuel oil, foreign bodies in the eyes, lumps of coal rolling down from the coal pile onto the feet of firemen, falls from ladders, scaffolding, etc. To eliminate them means that each case must be thoroughly investigated and ways found to remove the cause, if possible, if not, to provide a preventative measure. Such as, for instance, the man who investigates the contents of a fuel oil container with the aid of an open torch may need an electric torch, or perhaps an electric light permanently located.

No attempt will be made to enter into a discussion of mechanical methods of eliminating the hazards incident to furnace construction and repairs, furnace operation, charging floors, pouring platforms, disposal of product and waste material, and the like, because I believe that it will be more advisable to cover them in a general way from an educational standpoint.

Pouring Platforms.

Likewise, after it becomes a settled fact that the wearing of goggles and leggings are essential for protection during the operation of pouring steel, the steel pourer should be instructed that it is sufficient cause for his removal if he, or men helping him, do not use them during operations.

From paper read at the Iron and Steel section at the Congress of the National Safety Council, held in New York, September, 1917.



C. W. Johnson who was elected vice president of the American Institute of Metals at their recent meeting, is general superintendent of the East Pittsburgh works of the Westinghouse Electric and Manufacturing Company. Mr.



Johnson is a native of Ohio and a graduate of Ohio State University. He began his business career after graduation as draftsman with the Steel Motor Company of Johnstown, Pa., after which he became connected with the Bulloch Electric Company of Cincinnati in 1897 successively holding the positions of chief draftsman, engineer, and production manager. From 1904 to 1907 Mr. Johnson was superintendent of the combined Allis-Chalmers and Bulloch plants at Montreal, Canada. In the latter year he entered the employ of the Westinghouse Electric and Manufacturing Company as chief inspector. In 1909 Mr. Johnson was promoted to the position of assistant manager of works which position he continued to fill until 1912 when he was made general superintendent of works.

✓ ✓

Carl Oberstadt formerly with the Standard Parts Company, of Cleveland, has been employed by the Elyria Iron and Steel Company, as general superintendent of the Cleveland works.

✓ ✓

Reid L. Palmer formerly with American Tube and Stamping Company, is now connected with the Hartford Electric Steel Corporation, Rocky Hill, Conn.

✓ ✓

George M. Smith has accepted the position of chief engineer of the Interstate Iron and Steel Company, Chicago. He was formerly chief engineer for Walter Rachals and Company, Youngstown, Ohio.

✓ ✓

James A. Morris of the Brier Hill Steel Company, Youngstown, Ohio, has resigned his position in the auditing department to enter the employ of the Inland Steel Company, Chicago, in the same capacity. Mr. Morris was in the auditing department of the William Todd Company, Youngstown, several years ago.

✓ ✓

Frank Prunell of the sales department of the Youngstown Sheet and Tube Company, has been employed by the Priorities Committee in Washington to assist J. Leonard

Replogle in the purchase and distribution of iron and steel for the government.

✓ ✓

E. G. Burns is now chief chemist at the Trumbull Steel Company, Warren, Ohio, formerly at Canton, Ohio, United Alloy Steel Corporation.

✓ ✓

Edgar I. Mills resigned from the American Steel Export Company, October 1, to take up his duties with the iron and steel department of the Federal Export Corporation. He has been identified with the export branch of the steel industry for some years.

✓ ✓

Harold G. Carter, metallurgist, has left the South works of the American Steel and Wire Company, of Worcester, Mass., to become metallographist for the experimental station at the U. S. Naval Academy, Indianapolis, Ind.

✓ ✓

George Davies of the East Chicago plant of the Republic Iron and Steel Company, has been made superintendent. He was formerly assistant superintendent at the same plant.

✓ ✓

G. B. Wickersham is now vice president and general manager of the Louisville Steel and Iron Company, Louisville, Ky. He formerly occupied a similar position with the Diamond Forging and Manufacturing Company, of Pittsburgh, Pa.

✓ ✓

D. V. Sawhill for some months in charge of the pipe department of the Cincinnati Iron and Steel Company, Cincinnati, and previously in the sales department of the Youngstown Sheet and Tube Company, has resigned and has joined the Pennsylvania Signal Corps.

✓ ✓

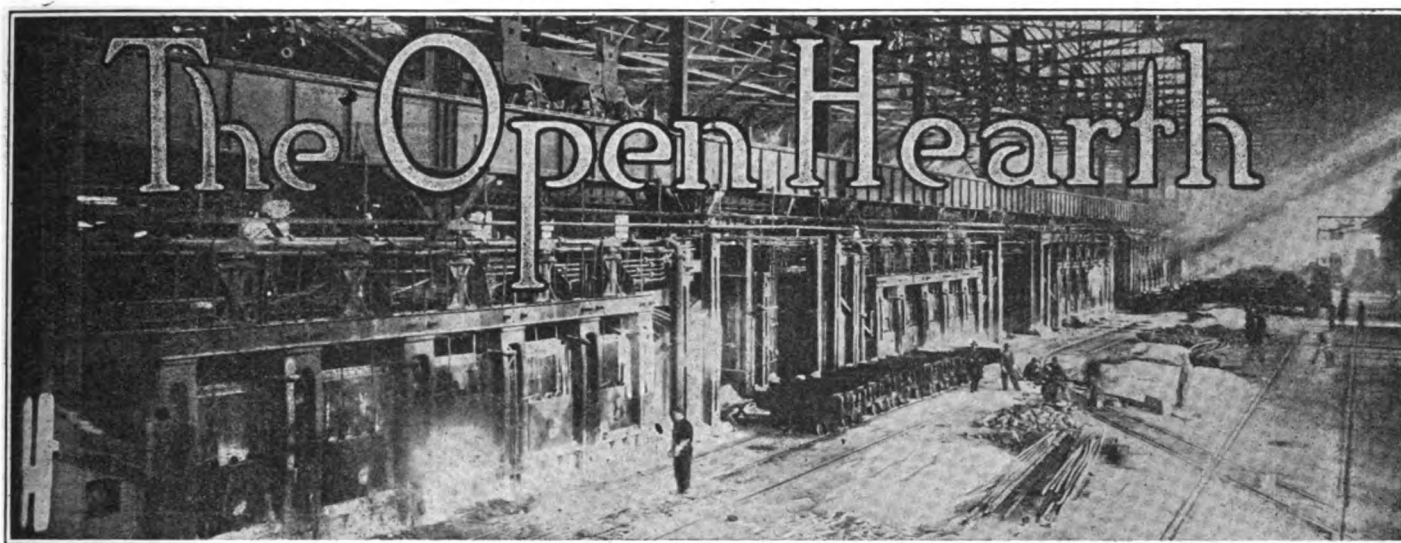
John Kenney of the American works of the Bethlehem Steel Company, Lebanon, Pa., is now in employ of the Standard Iron and Steel Company, of Burnham, Pa., as assistant superintendent.

✓ ✓

Arthur D. Fiske has been appointed assistant division freight agent in charge of traffic in the Worcester district. The appointment was made by President William P. Palmer in appreciation of Mr. Fiske's 33 years of faithful service to the American Steel & Wire Company, at Worcester, Mass.

✓ ✓

I. Peterman, formerly chemist for the Birmingham Trussville Iron Company, Trussville, Ala., is now chemist for the C. I. & C. Co., Holt, Ala.



At the recent annual convention in Boston, the American Foundrymen's Association elected Benjamin D. Fuller of Cleveland, president for the following year. Mr. Fuller is the superintendent of foundries of the Westinghouse Electric and Manufacturing Company. Mr. Fuller was born in South Scituate, Mass., and after public school and a short business college training, went to work in the Pittsburgh Locomotive Works in 1881 as a molder. During the next 10 years he worked in the foundries of the Westinghouse Machine Company, the Fort Pitt Foundry, and the Fuel Gas and Electrical Engineering Company. Com-



ing to the Westinghouse Electric organization in 1891, he worked his way up through the various grades to be superintendent of the company's Allegheny foundry, and later to be superintendent of all the company's foundries. Since the largest of these is at Cleveland, Mr. Fuller makes his headquarters at that point.

V V

William A. Moore, formerly with the Tonawanda Iron & Steel Company, Tonawanda, N. Y., is now with the Hershell-Sueilman Company, North Tonawanda, N. Y.

V V

O. W. Black has entered the employ of the Fulton Iron Works Company, of St. Louis, as works manager. He formerly held a similar position with the Republic Iron and Steel Company, of Youngstown, at the Mahoning Valley works.

V V

Theodore L. Wagner for 27 years employed by the Stanley works, New Britain, Conn., and who was recently foreman of the excess layout department, is now superintendent of Stanford Steel Products Company, Milford, Conn.

V V

Paul L. Keiser is president of the newly organized Pottstown Steel Products Company. The plant of this concern is now nearing completion and Mr. Keiser is no longer connected with the Eastern Steel Company's, Pottstown, Pa., plant.

V V

F. L. Converse has recently resigned as chief steam engineer of the Worth Brothers' Company, at Coatesville, Pa., to become steam and electrical engineer for the Tacony Ordnance Corporation, at Tacony, Philadelphia, Pa.

V V

Professor A. M. Buck is now associated with John A

Beeler in consulting engineering work with offices at 52 Vanderbilt avenue, New York City. Professor Buck has had charge of electric railway work at the University of Illinois since 1911. Prior to that time he was connected with the Westinghouse Electric and Manufacturing Company, and various engineering colleges.

V V

R. A. Field, formerly of the Broken Hill Proprietaries Company, Ltd., New Castle, N. S. W., Australia, is now blast furnace superintendent of the LaFollette Coal & Iron Company, LaFollette, Tennessee.

V V

Dudley R. Kennedy of the Youngstown Sheet and Tube Company, has been chosen by Governor J. M. Cox of Ohio, as a member of a commission to study health, old age insurance and sickness prevention as a basis for state legislation. Mr. Kennedy is employed as assistant to the president of the Youngstown Sheet and Tube Company.

V V

R. D. Junkins, formerly chief engineer of power stations with the Pittsburgh Crucible Steel Company, of Midland, Pa., is in training at Camp Lee, Petersburg, Va.

V V

R. S. Gordon, formerly melter foreman with the Carnegie Steel Company, occupies a similar position at No. 2 open hearth with the Lackawanna Steel Company, Lackawanna, N. Y.

V V

J. F. Spellacy has accepted a position with the American Steel Foundry Company, at Indiana Harbor, Ind., as master mechanic. He was formerly with the Illinois Steel Company, at South Chicago.

V V

Major L. J. Campbell, a vice president of the Youngstown Sheet & Tube Company, is now in command of a battalion of heavy artillery at Camp Sherman, Chillicothe, O.

V V

R. A. Butler, formerly safety inspector at the American Steel Foundries Company, Sharon, Pa., has changed his position to take charge of all safety work for the Ashland Iron & Mining Company, and Ashland Coal & Iron Railroad, at Ashland, Ky.

V V

A. W. Hubbard has been elected president of the Charleston Alloy Steel Company, Belle, W. Va. He was assistant to the president of the Andrews Steel Company, and Newport rolling mills for the past 26 years.

Some Pointers on By-Product Coke Oven Operations

COKE IN BLAST FURNACES.

By C. J. Ramsburg and F. W. Sperr, Jr.

There is at present some disagreement among blast-furnace men as to the exact function of the coke in the most efficient and economical reduction of iron ore. The majority probably still accept Gruner's theory of ideal working, viz. (as stated by Richards), "All the carbon burnt in the furnace should first be oxidized at the tuyeres to CO, and all reduction of oxides above the tuyeres should be caused by CO, which thus becomes CO₂." It is well known that the reduction of iron oxide by carbon monoxide is the most efficient from the standpoint of heat economy. Richards, however, has pointed out that the direct reduction of iron oxide by carbon is three times as efficient from the standpoint of carbon required as the indirect reduction, and says:

"The ordinary furnace produces at the tuyeres, in order to get heat enough to melt down the charges, more CO gas than is needed to abstract all the oxygen from the charges; under these conditions it is uneconomical to oxidize any carbon at all above the tuyeres. The exceptional furnace, because of pure ores, small amount of slag, pure fuel, high temperature of blast, or dry blast, gives heat enough at the tuyeres to melt down the charges without producing enough CO gas to reduce all the charges; under these conditions, more or less reduction is effected by solid carbon and with the greatest economy in quantity of carbon required in the furnace."

About a year ago H. P. Howland prepared an interesting paper, entitled "Calculations With Reference to the Use of Carbon in Modern American Blast Furnaces," calling attention to the fact that many furnaces are actually operating with higher economy of coke than would be calculated from Gruner's theory; in fact, his calculations on the performance of 26 furnaces seem to show that what Richards regarded as the exceptional furnace is the rule rather than the exception in modern practice.

Howland's tabulation of data on these 26 furnaces is so interesting and pertinent to the subject that a portion of it is reproduced in Table 4.

Note incidentally the performance of the once-despised by-product coke in modern practice. Of the 19 furnaces using less than a ton of coke per ton of pig iron, 13 are burning by-product coke and 6 beehive coke.

Howland calculates that all the furnaces burning less than 1,350 lbs. of carbon at the tuyeres are not making enough CO to reduce all the Fe₂O₃ and hence some of the latter must be reduced directly by carbon. He concludes: "It seems clear, therefore, that in low-coke furnaces one of the most important (if not the most important) functions of the carbon burned at the tuyeres is to produce heat to enable the carrying on of the direct reduction, rather than to produce CO for indirect reduction.

"On this basis, it becomes very essential that our carbon shall burn instantaneously to CO in order that the resulting heat may be localized where needed. This should not be a question of seconds, but of a fraction of a second. If our carbon is of such a nature that this burning to CO is a comparatively long process, more of it will be required than of

From a paper presented at a joint meeting of The Franklin Institute and the Philadelphia Section of The American Society of Mechanical Engineers, February 1, 1917.

Table 4—Part of Howland's Data on American Blast Furnaces.

Furnace No.	Pounds coke per ton iron	Tons iron per day	Carbon in coke, per cent	Kind of method of manufacture	Coke operation	Total charged	Gasified in furnace.	Gasified at tuyeres	Per cent total carbon	Per cent gasified carbon
1	2,615	301	86.3	BH	Stonega	2,254	2110	1868	82.8	
2	2,551	272	84.4	BP	Solvay	2,153	2049	1751	81.4	86.6
3	2,472	482	86.1	BH	Conn.	2,128	1996	1728	81.2	86.8
4	2,247	450	87.1	BH	Conn.	1,957	1846	1605	82.0	87.0
5	2,198	499	86.9	BH	Conn.	1,908	1810	1494	78.7	82.6
6	2,123	541	88.3	BH	Conn.	1,875	1764	1498	79.8	84.9
7	2,115	360	84.3	BP	Solvay	1,782	1683	1427	80.1	84.8
8	1,996	490	86.3	BP	Koppers	1,722	1611	1298	75.4	80.6
9	1,936	376	85.7	BP	Solvay	1,659	1567	1305	78.8	83.7
10	1,905	393	88.7	BP	Solvay	1,600	1575	1252	74.1	79.5
11	1,901	517	85.5	BP	Koppers	1,625	1524	1280	78.8	84.1
12	1,863	504	86.6	BP	Koppers	1,614	1513	1230	76.2	81.3
13	1,780	426	84.9	BP	Koppers	1,511	1414	1124	74.4	79.5
14	1,742	503	84.6	BP	Koppers	1,474	1382	1133	76.9	82.0
15	1,716	542	87.1	BH	Benham	1,494	1396	1194	80.0	87.0
16	1,715	585	84.6	BP	Koppers	1,451	1357	1114	76.6	82.2
17	1,702	543	87.5	BP	Koppers	1,490	1388	1130	75.9	81.5
18	1,690	572	87.0	BP	Koppers	1,479	1387	1155	78.2	83.4
19	1,673	580	88.6	BH	Benham	1,482	1384	1182	79.9	85.0
20	1,658	590	88.3	BP	Benham	1,464	1366	1182	80.8	86.5
21	1,636	442	89.5	BP	Koppers	1,463	1369	1124	76.8	82.1
22	1,635	503	88.5	BH	Benham	1,447	1349	1124	77.7	83.4
23	1,624	592	87.3	BH	Benham	1,417	1317	1118	79.0	85.0
24	1,623	457	89.6	BP	Koppers	1,454	1360	1090	75.0	80.2
25	1,589	608	88.3	BH	Benham	1,403	1307	1100	78.5	84.2
26	1,584	466	89.2	BP	Koppers	1,413	1324	1057	74.8	79.9

Note—BH = Beehive. BP = By-product. Conn = Connellsville.

the quick-burning carbon in order to obtain the same concentration of heat at the desired point.

"We would, therefore, say that the most desirable thing about a coke is that quality in the carbon which will allow of its being instantaneously burned to CO and thus result in the maximum concentration of heat where needed."

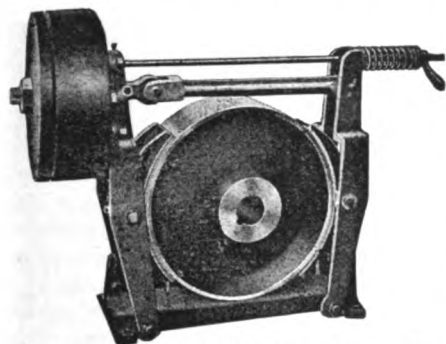
W. H. Blauvelt, in a discussion of Howland's paper, says: "In studying the combustion of coke in the furnace, it is clear that the production of the maximum quantity of heat is not of the first importance in blast-furnace operation, or in the utilization of the fuel charged into the furnace. To my mind, the production of a high thermal head at the tuyeres is of the first importance, and the best coke is that which reaches the tuyeres in proper condition to produce the highest temperature at the tuyeres, and in just sufficient quantity to do the amount of work required there under the conditions produced by this maximum temperature. The combustion of a much larger amount of fuel at the tuyeres, under conditions that will fall short of producing the highest possible temperature, cannot produce as good results, either in fuel economy or output. . . . Nothing is more fatal to obtaining the highest temperature than an excess of combustion. In the blast furnace an excess of air dilutes and cools the products of combustion reducing the maximum thermal head at the tuyeres, and the larger volume carries the high temperature zone too high in the furnace. . . . It will probably be generally admitted that furnace coke should be of nearly uniform size, and many furnace managers are eliminating all coke below ¾-in. and above 4 or 4½-in.; also, that the best coke is that which is sufficiently strong to resist undue abrasion and crumbling by attrition with the stock, and of an open porous structure that will permit the most rapid combustion when it reaches the tuyeres. Many large users agree that the coke should never be overcooked beyond the point of producing a sufficiently strong structure, as overcoking quickly reduces the combustibility.

WITH THE EQUIPMENT MANUFACTURERS

MOTOR AND MAGNET-OPERATED BRAKES.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., has brought out two new types of brakes. Types RS and M are the terms designating an alternating current motor-operated brake, and a direct-current magnet-operated brake, respectively. The alternating current brake with motor operation has been generally found to be more suitable than one depending on solenoid or magnet operation because of the inherent characteristics of a. c. solenoids being

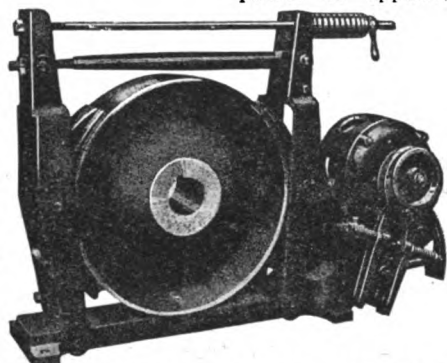
unsuitable for braking service. The motor-operated brake is silent in releasing, in applying and while held released. A high torque squirrel cage motor is employed geared to a toothed sector which is linked to the arms carrying the brake shoes. When power is applied,



Motor-operated brake for alternating current service.

the motor revolves until the brake is released. It then stalls and maintains the brake in the released position until power is cut off. One of the outstanding features to be noted is the ease of making adjustments of brake for wear by means of simply turning a nut on the end of the thrust rod which is the upper rod shown in the accompanying illustration. This adjustment is required only two or three times during the life of the brake lining. These brakes are made in sizes ranging from 8 to 30 inches, with ratings up to 250 horsepower.

The direct current magnet or solenoid brake shown in the second illustration is similarly constructed, but has a magnet in place of a motor, the direct-current magnet being eminently suited for brake operation. Six standard sizes ranging from 8 to 27 inches with horsepower ratings like the motor-operated type RS brake mentioned above. Brakes of this construction are particularly suited for severe service.



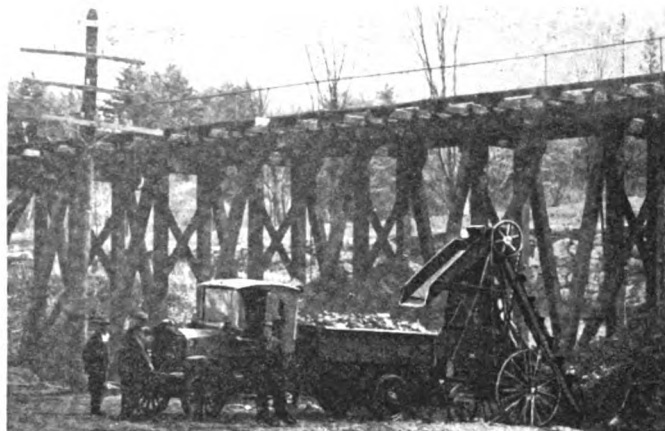
Magnet-operated brake for alternating current service.

COAL TRUCK LOADER.

Being confronted with the problem of loading coal from their ground storage pile by other means than hand shovelers, the American Optical Company of Southbridge, Mass., found a solution by purchasing a Link-Belt wagon and truck loader. This machine loads the material at the rate of one ton per minute and requires but one man for operating, thereby cutting down the operating costs. Their situation was a peculiar one in that the coal storage pile was some distance

from their power house, and thus required transportation and transferring of coal before it reached the boilers. The truck is kept on the "go" constantly as it requires only a few minutes to load it.

The bituminous coal arrives by the carload and dumped from the trestle to the ground storage pile. It is then



Wagon and truck loader being used for loading coal into auto trucks for delivery to power plant.

loaded into trucks by the Link-Belt loader for transportation to the power house where it is again transferred and fed to the automatic boiler stokers.

The automatic loader illustrated is operated by electric motor and loads the truck shown beside it in about five minutes. With the use of this machine they have reduced the cost of handling their coal, as well as gravel, over 50 per cent, and the same machine is also used in their sand bank, with very good results. It enables them to handle in one day, as much as was formerly handled in two days. Not long ago they loaded 80 square yards of earth which was carried one-half mile round trip by a two-ton truck in one day.

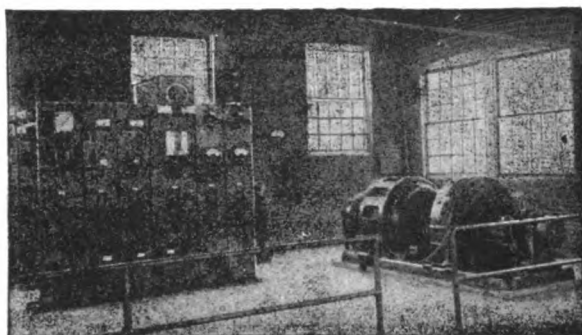
SWITCHBOARD PANEL STANDARDIZATION.

There are many power-station operators to-day who still remember the time when electrical power was in its infancy—the time when controlling devices were so inadequate that the "knife-switch" opened with a flaming arc in trail—an arc which was then beaten out with a leather thong. In those days it became evident to many that electricity must be better controlled if its best promises were to be fulfilled. Inventive genius was set to work to produce improved devices for the control of every sort of current, and in time the modern switchboard was evolved.

After the slate or marble panel, with its controlling and measuring instruments and its tripping devices for opening circuits at a sign of danger, was firmly established, a need for a uniformity in material, size and equipment became evident. However it was thought by many that a complete standardization such as had revolutionized industries and trades would be impossible in switchboard manufacture.

WITH THE EQUIPMENT MANUFACTURERS

But the switchboard specialists of the General Electric Company saw things in a different light. To substantiate their views they had a vast experience with cases which showed conclusively that most control needs fell into distinct classes whose requirements could be met by standardized material. Thus it happened that there was developed a complete classification of switchboard needs together with a



Greensburg Coal Company, hoist house showing 200 kw. synchronous motor generator set, switchboard and 2300 volt air brake contactors for reversing hoist.

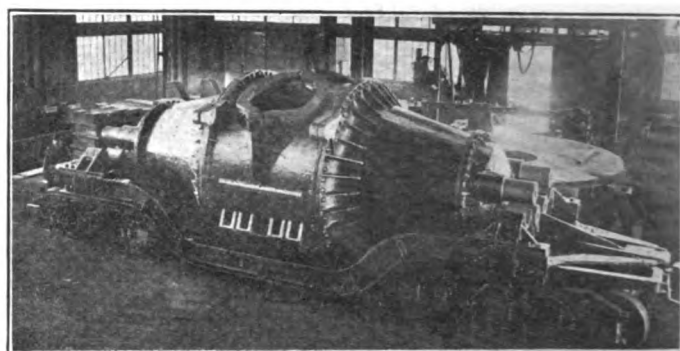
standardization of the apparatus manufactured to meet these needs. Panels became units and thousands of them, after being described and assigned catalogue numbers, were listed in books covering many phases of the electrical industry.

To-day it is possible for station owners and users of electrical power to order switchboards of a great many sizes and capacities directly from a catalogue. Much of the worry, delay, and expense of specifications and drawings has been eliminated and in its place stand the advantage of quantity production and concentrated skill in design. Of course, various cases still exist which require individual switchboard engineering, but a great many switchboard conditions may be met by these "standard unit" panels. Because of this and because of the saving in time, trouble and money which results from their use, "standard unit" panels are said by some engineers to be one of the greatest advances in the switchboard engineering of recent years.

NINETY TON HOT METAL CAR.

The accompanying illustration shows a new type of car for transferring molten metals. The car is a 90 ton hot metal car, built by M. H. Treadwell Company, of New York and it undoubtedly marks a new and advanced step in the practice heretofore in vogue. John D. Pugh, engineer, Baltimore, Md., is the inventor and patentee. A car of this design has been furnished to the Jones & Laughlin Steel Company, and is giving very excellent results. Some of the many obvious advantages of this car may be here enumerated as of interest to users of such equipment from both a commercial and engineering standpoint: (1.) The carrying of much larger bodies of metal than heretofore practicable, thereby reducing the dead weight of cars required to transport a given tonnage, and as fewer cars, wheels, journals, etc., are used the wear and tear and cost of repairs is materially reduced. (2.) The conservation of heat owing to the enclosed construction which will deliver blast furnace iron to the steel plant much hot-

ter than other types of car, and in actual practice extreme delays of several hours duration have had no detrimental effect on the fluidity of the charge. (3.) "Sculling" is entirely eliminated. If the ladle should not be completely emptied at any time it has been found that succeeding casts will cut all material so left, and the ladle will prove entirely self-cleaning. (4.) By a proper arrangement of iron runners at the blast furnace the length of same can be very materially shortened and the number of spouts reduced from, say 4 or 6 to 1 or 2, depending on the size of car used. This will cut down the cost of labor in cleaning runners, and the amount of skull in the runners, and is of especial interest in the construction of new plants, as the runners and sizes of cast house building and floor being less, construction costs will be proportionately lower. (5.) The car illustrated has about 94 gross tons capacity, but it can be easily made much larger with resultant increase in commercial efficiency. Increase in length will increase capacity without increasing side or head clearances. (6.) The circular form of construction in the body gives maximum strength to the body as a beam supported at its ends. (7.) The construction of the trucks is particularly adapted to this class of equipment and is very satisfactory, the so-called arch bars or frames being compensating or hinged to enable the three wheels on each side of truck to bear equal loads under all conditions. (8.) In the car shown the body of the ladle was made of steel castings. Steel plate construction can be just as easily used.



Ninety ton hot metal car manufactured by the Treadwell Engineering Company. The closed construction enables the maximum conservation of heat.

the choice of material depending on the relative cost of same and desire of the customer. This body is made in flanged sections held together by bolts, which in the remote event of a charge being allowed to freeze or for any other reason, will allow the sections to be separated and the entire lining to be readily removed by a pusher in the manner now usually practiced. The ladle body is supported and tilted on trunnions in the usual manner.

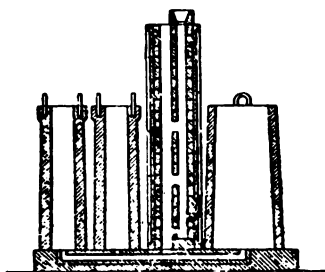
NEW HEAVY DUTY WAR TRUCK.

The first truck built according to the designs of the Society of Automotive Engineers for war service has been completed and started on the road. These trucks are designed for 3 ton load but with 5 ton capacity. The dispatch with which this machine was designed and assembled marks a new record in American production. The completed

RECENT PATENTS

Pouring Head for Ingot Molds.

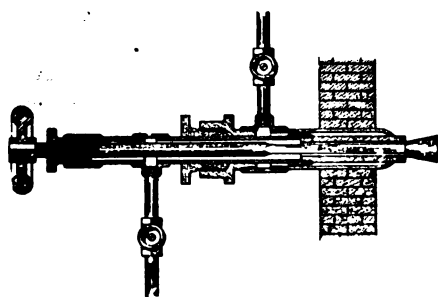
1,240,722. Charles L. Huston, Coatesville, Pa. The patent consists of a combination of a pouring head, with a base plate. The pouring head is divided into two channels by a series of molded bricks having two openings. The purpose of the two channels is for pouring in molten metal and allowing the escape



of gases. One channel is of greater diameter than the other. The base brick has a single opening in line with the large vertical channel and forms an abutment for the molten metal as it flows into the smaller channel, the opening forming a communication between the opening in the vertical channels and the opening in the base plate.

Oil Burner.

1,242,567. John E. Limbacher, St. Marys, O. The burner comprises a sectional oil inlet pipe which is enclosed, at its discharge end, by a steam inlet pipe. The steam pipe is provided with a series of jet openings. The oil supply



is controlled by a feed rod having a conical-shaped head, thus carrying the oil to be discharged in a cone-shaped film immediately ahead of the steam jets. The patent includes the coupling member for the steam supply and the packing gland sealing the steam joint.

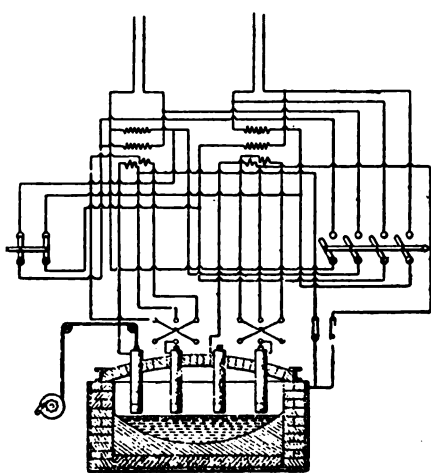
Tube Rolling.

1,240,513. George J. Thrust, of Milwaukee, Wis. This invention relates to improvements in tube rolling apparatus, and has for its object the providing of new and improved apparatus by the use of which a finished tube can be produced in a minimum of time and with a min-

imum of labor and consequent expense of rolling. Hitherto it has been necessary to subject the billet after piercing to a number of operations causing a lack of continuity in rolling, and in many instances requiring one or more reheats of the tube. This apparatus overcomes these objections and, as stated, reduces the number of operators required to produce the tube. Another object of the invention is to provide an apparatus of this nature in which a mandrel is used in conjunction with planishing or forming rolls, the mandrel being mounted upon a bar, this bar being held at one end while the tube is being rolled over the mandrel, the rolls and mandrel being so arranged that the tube is drawn off the mandrel rather than pushed over. By this improved feature the mandrel carrying bar is subjected to tensile stresses only, and as a consequence may be made much lighter and smaller in size, reducing the amount of power required and the cost of the bar. Furthermore, by so handling the tubes and bar it is necessary to have the bar only slightly longer than the tube to be rolled.

Electric Furnace.

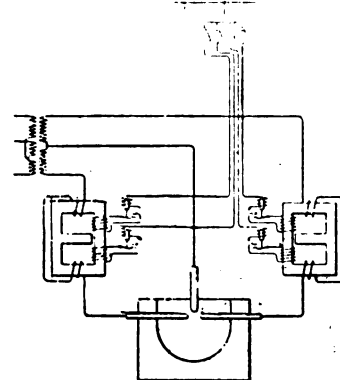
1,242,464. William E. Moore, Pittsburgh, Pa. The patent covers an electric metallurgical furnace and the meth-



od of operating same. The transformer primaries are connected delta and the secondaries connected star when melting or heating the metal to refining temperature. The primaries are connected on connected star and the secondaries delta for refining the metal. Sub-sections of the transformer primaries or secondaries, or both, are connected in series on multiple to further vary the voltage as between the heating or melting and refining operations. The furnace is bottom heated and has three arcing electrodes supplied with current from a three-phase transformer system.

Electric Furnace Control.

1,242,250. John A. Seede, Schenectady, N. Y., assignor to General Electric Company. The patent comprises the combination of an electric furnace, a supply



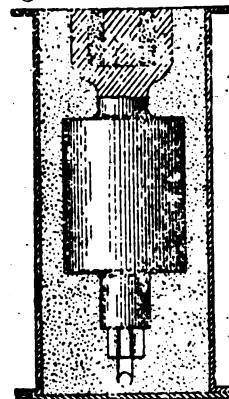
circuit, a reactance coil, a secondary coil in inductive relation with the reactance coil, and means for controlling the current in the secondary coil to vary the reactance of the furnace supply circuit.

Checker-Work.

Patent No. 1,242,614 has been granted to Horace E. Smythe, of Pittsburgh, Pa., in which the following is claimed: A checker work for regenerative furnaces, hot-blast stoves and the like, comprising horizontal courses of bricks, each brick having end depressed portions and a central transverse depressed portion, the bricks in each course being arranged in parallel lines and each line being composed of bricks arranged end to end and each course being arranged at right angles to the next course below it with the abutting ends of the bricks in one course seated in and resting upon the depressed portions of the bricks in the next course.

Process of Casting Rolls.

1,242,827. Harold A. Lomax, Aspinwall, Pa. The process calls for a bottom pouring method when casting rolls,



and more metal is poured in at the top of the mold while the main body is still molten, this latter metal being at a higher temperature.

Trade Publications

Graphic Recording Instruments.—The Esterline Company, of Indianapolis, has published an illustrated pamphlet describing their graphic efficiency instruments the application of which covers the entire field of electrical industry and all branches of manufacturing and operating.

Pyrometers.—Bulletin No. 860, issued by the Leeds & Northrup Company, of Philadelphia, Pa., shows their optical pyrometer, its advantages and some illustrations showing method of use.

Elevating and Conveying.—Link-Belt Company, of Chicago, has issued book No. 3430 folder No. 340 describing the Watson Type Rope Tramway System and a Link-Belt sand and gravel washery respectively. These pamphlets reveal some interesting features of design and construction.

Foundry Equipment.—Whiting Foundry Equipment Company, of Harvey, Ill., have published catalogs—128, 129 and 131 on foundry equipment. These catalogues supersede old ones of the same titles and contain revised data and some new cuts.

Hand Trucks.—The Cowan Truck Company, of Holyoke, Mass., has issued a new pamphlet on the construction and industrial application of Cowan trucks. The feature of the construction is the use of Hyatt-Roller bearings throughout.

Steel.—"Steel" issued monthly by Peter A. Frasse & Company, New York gives list of stock ready for immediate shipment. This firm also announce the distribution of their new cloth bound catalogue on Frasse-Steel and authoritative information as to their users, etc.

First Aid.—Johnson & Johnson of New Brunswick, N. J. have recently published an illustrated catalogue No. 110 showing their complete line of first aid products and a list of the publications.

Thermit.—The Goldschmidt Thermit Company, has published the third issue of their pamphlet on carbon, free metals and alloys.

Export.—A new twenty-four page pamphlet has been issued by the American Steel Export Company, giving the groups of countries and lists of materials effected by the President's proclamation also subsequent orders together with fac-similes of forms prescribed and an explanation of their use.

Titanium Aluminum Bronze.—The Titanium Bronze Company, of Niagara Falls, N. Y., has published a booklet descriptive of the properties of Titanium Aluminum Bronze. It is said to have the strength and toughness of manganese bronze, the wearing qualities of phosphor bronze combined with superior acid resisting properties.

Electric Control.—The latest binder

issued by Allen-Bradley Company, of Milwaukee, Wis., contains complete revised bulletins on their product. These bulletins give the list prices ratings, etc., also specification and installation data including detail cuts and dimension and wiring diagrams of the various devices. The graphite compression type of resistance is used throughout and is the feature of their construction.

"Utility Letters of Credit in the Export Trade — A Plea for Standard Forms," is the title of a new pamphlet issued by the American Steel Export Company, of New York. In this article the author, J. P. Beal, who is secretary and assistant treasurer to this company, makes recommendations that should be heeded by the American banker and exporter. He has indicated a point of weakness which might be improved materially, a point which to him seems worthy of immediate attention and to the betterment of the entire overseas financial facilities.

Trade Notes

In order to take care of its rapidly growing business in Cuba, the Vulcan Steel Products Company has opened an office in Havana, under the management of G. O. Simpson. Within a year from its incorporation on September 27, 1916, Vulcan has built up an export business in steel and iron, machinery, and similar lines which in August alone, amounted to \$8,000,000.

The West Michigan Steel Foundry Company, Muskegon, Michigan, will install a 3-ton Booth-Hall electric steel furnace, capable of producing 30 tons per 24 hours. This is the same size as the Booth-Hall furnace which will be put in operation by the Midland Electric Steel Company, Terre Haute, Indiana, early in November. The Duriron Casting Company, Dayton, Ohio, will install a 34-ton Booth-Hall furnace for producing the special non-corrosive Duriron.

Owing to unprecedented increase in increase in their business The Brown Instrument Company, of Philadelphia, Pa., acquired property adjacent to their plant for future extensions.

The Walter C. Zelnicker Company, of St. Louis has secured the services of W. H. Bramman as assistant to the president.

Westinghouse Electric & Manufacturing Company, has announced another wage increase for shop employees aggregating approximately \$2,000,000 a year. Increase will be in the form of a bonus for all employees except munition workers observing shop hours. Ten per cent for those on salary or time-rate basis and 7 per cent for those on piece work.

William A. Battey, who has been connected with the Shepard Electric Crane & Hoist Company since its start in this field, as Eastern sales manager and sales director, will sever his active con-

nection with the business on December 1, but will retain his interest in the company and continue as a director. Mr. Battey, who is vice president of the Pennsylvania Crusher Company, finds it necessary to devote his entire attention to its rapidly expanding business in the manufacture of hammer pulverizers, Bradford breakers and special crushing machinery for the by-product coke industry and other industries requiring reduction apparatus. W. C. Briggs, who for the past 10 years has been associated with Mr. Battey in the Shepard company's New York office as sales engineer, will become district manager. On November 1, Robert T. Turner will join the New York organization as sales engineer and as additional salesman and service man will shortly be located in the company's new offices at 30 Church street.

The Electric Furnace Construction Company, Finance building, Philadelphia, announces the following sales of Greaves-Fitchells electric furnaces: American Radiator Company, Buffalo, N. Y., second order for a six-ton furnace; Stoddard Union Company, Lockport, N. Y., one-ton furnace; Primos Chemical Company, Primos, Pa., one special furnace for ferro-alloys; T. Waddell & Sons, New Zealand, one two-ton furnaces. The company also announces that Frank Wharton Brooke, formerly metallurgist at Crowley's, Detroit, and at the Ludlam Steel works, and G. W. Ketter, who has just finished the erecting and installation of 10 six-ton furnaces at the British Forgings, Ltd., Toronto, Ont., and who has been erecting and superintending electric furnaces for years, have joined their staff at Philadelphia.

Society Meetings

Engineers' Society of Western Pennsylvania, Union Arcade, Pittsburgh, November 13.

Joint sessions of Pittsburgh and Cleveland sections of A. I. S. E. E., Cortland House, Canton, O., November 24.

Pittsburgh section A. I. S. E. E., Youngstown, O., December 15.

American Society of Mechanical Engineers, New York City, December 26-29.

American Mining Congress, State Chapter, Phoenix, Ariz., December 26-29.

American Society of Mechanical Engineers. Monthly meeting, first Tuesday. Calvin W. Rice, secretary, 29 West Thirty-ninth street, New York City.

Providence Engineering Society. Monthly meeting, fourth Wednesday of each month. A. E. Thornley, corresponding secretary, P. O. Box 796, Providence, R. I.

New England Foundrymen's Association. Regular meeting, second Wednesday of each month, Exchange Club, Boston, Mass. Fred F. Stockwell, 205 Broadway, Cambridgeport, Mass.